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JANUARY, 1943.

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THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY

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FRACTURES OF THE FEMUR IN WAR-TIME: A REVIEW OF THIRTY-TWO CASES.¹

By B. T. KEON-COHEN,
Captain, Australian Army Medical Corps.

BETWEEN the latter part of May, 1941, and January, 1942, thirty-two patients suffering from fractures of the femur were admitted to, and treated at, an Australian general hospital in Palestine (see Table I). Many of the fractures were in the nature of ordinary "civilian" injuries. These presented no special problems in management other than those encountered in peace-time practice. There were, however, fourteen compound fractures of the neck or shaft of the femur, resulting from gunshot wounds of the thigh. In this account particular reference will be made to these cases and special problems which arose during their treatment will be discussed.

EQUIPMENT.

The matter of equipment is of such vital importance in a military hospital overseas that reference to it in this paper is not out of place. Under the Army scale adequate supplies of Thomas splints, Balkan beams *et cetera* are provided for the transport and treatment of patients suffering from fractures of the femur, together with the necessary appliances for applying traction.

The modified Balkan beam which has been used for some time in Perth by Lieutenant-Colonel F. J. Clark, Officer Commanding the Surgical Division, is of particular interest, and has proved almost ideal for military conditions. It has the inestimable advantage of forming with the bed and patient one complete mobile unit. As the season advanced, and it became necessary to move the fractured femur patients from the original tented ward to "winter quarters" in a hutted ward, no trouble was experienced. The bed, splint and patient were simply lifted *in toto* onto a trolley and wheeled some three hundred yards over fairly rough going, without in any way interfering with the traction (Figure III).

TRANSPORT.

The transport of patients with gunshot wounds causing fractures of the femur has always presented one of the most difficult problems that the medical services have to face. During the early years of the 1914-1918 war the mortality among these cases reached the appalling proportions of well over 70%. This was reduced to less than one-third of this figure by the

¹ Accepted for publication on May 8, 1942.

universal adoption of the Thomas splint as a means of securing immobilization during transport from forward areas to base hospitals. For general purposes no better method has yet been devised. Table II gives the ascertainable

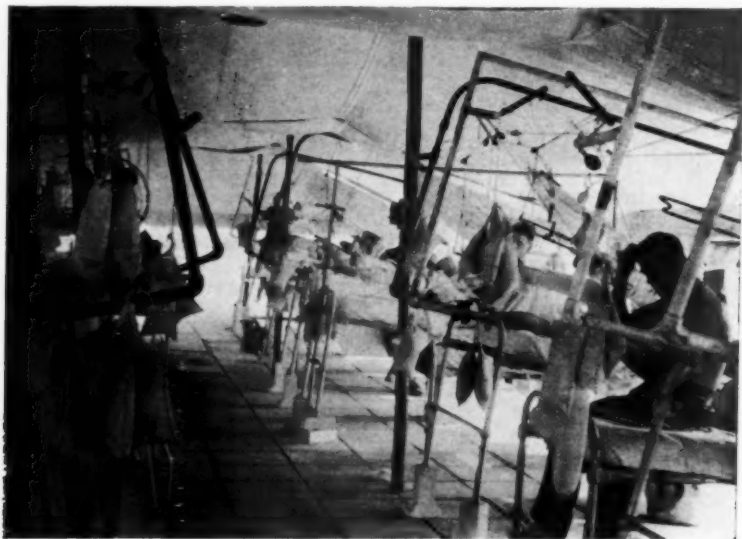


FIGURE I. A tented ward.

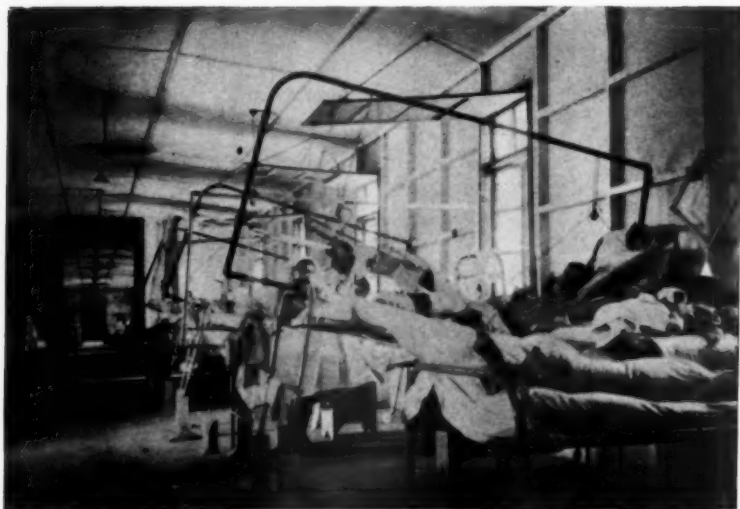


FIGURE II. A hutted ward.

details of the transport of these soldiers from the time of wounding to their ultimate arrival at this hospital. It should be noted that in many instances the journey took two or more days. This was due partly to the distance

behind the battle zone that base hospitals are situated in modern warfare, and partly to the fact that most patients were retained at a casualty clearing station or similar forward unit until they had recovered sufficiently to make the remainder of the journey by motor ambulance and ambulance train with reasonable safety.

One has only to view the terrain over which most of the Syrian campaign was fought to understand why some soldiers lay out for such long periods before being picked up and why some of the "carries" to the regimental aid

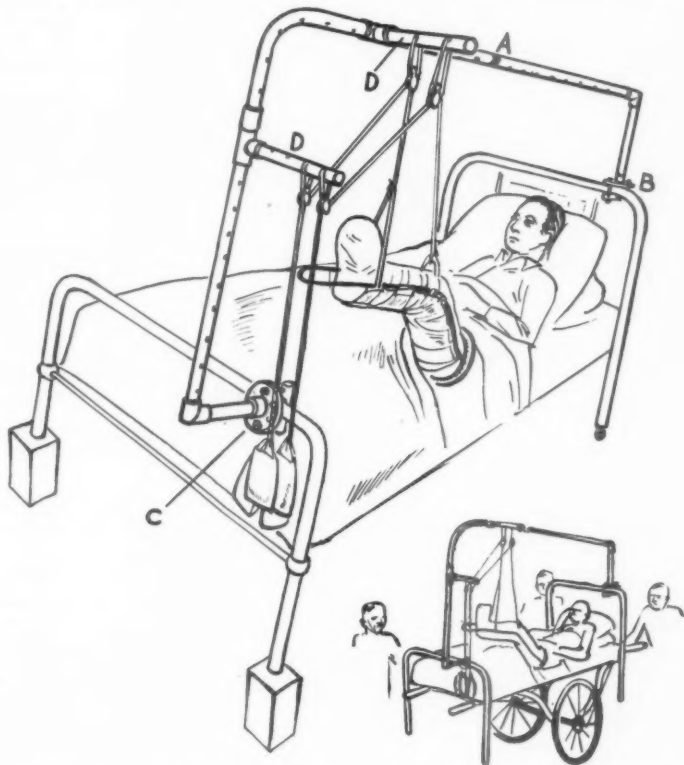


FIGURE III. Modified Balkan beam. It consists of two portions of steel piping one inch in diameter which are joined by a sliding metal rod at A. Multiple holes are drilled in the piping for the purpose of fixing adjustable limbs, D and D', in any desired position. The whole is attached to the bed by simple clamps made from plumbers' flanges, B and C. The frame thus becomes an actual part of the bed and can be moved wherever it is desired to move the bed. In moving over long distances and from ward to ward the whole bed is lifted onto a trolley and there is no interference with the extension apparatus. The materials used were: (a) discarded one-inch piping from truck canopy frames, (b) standard plumbers' fittings, (c) standard bolts. The cost was small. The piping was obtained for nothing and the necessary fittings for twenty frames cost £13 10s., Palestine.

post took so long. Stretcher bearers generally improvised some form of immobilization. A favourite method was to tie the legs together and then fix them either to the stretcher itself or to a rifle. It will be noted that in most cases, after a Thomas splint had been applied to the injured limb, the remainder of the journey was made in comparative comfort.

"Fixed" traction to the foot of the splint, the counter-traction being transmitted through the ring to the ischial tuberosity, is the method

universally used to secure immobilization of the limb. When a soldier, with his leg so put up in a Thomas splint, complains of pain, it is almost certain that the extensions require attention. They will usually be found to be either too loose or too tight.

If they are too loose a very simple adjustment, especially if the "Spanish windless" system of maintaining tension has been used, is generally all that is required to relieve such discomfort. Several soldiers complained of pain during the latter part of their journey by ambulance train. Inspection of their extensions on arrival at this hospital showed that this adjustment had not always been carried out.

The extensions are not infrequently found to be too tight when the "halter" method of applying traction is used. Briefly, this consists of applying a modified clove hitch over the foot, generally with the boot on, and tying the free ends of the bandage to the end of the splint. It has one very great disadvantage. Unless the limb is carefully watched, and the bandage loosened from time to time, a pressure sore will inevitably form where the bandage crosses the dorsum of the foot. This precaution was badly neglected in Cases VI and VII, with disastrous results.

The claims of the plaster spica as a means of immobilizing fractured femurs during transport to base hospitals have received considerable impetus of late, owing to the undoubted success of this method in the treatment of patients evacuated from Tobruk. It must be remarked, however, that there were many special circumstances which made this not only possible but almost imperative. All patients were evacuated by sea. This required many "lifts", and considerably more man-handling than usual. In addition, the evacuation was all carried out under the strictest "blackout" conditions, generally on moonless nights. In such circumstances the spica was obviously preferable to any other form of immobilization. It was indeed fortunate that at Tobruk there was a fully equipped Australian general hospital, numbering two orthopaedic surgeons amongst its surgical team, with proper facilities, both for applying the spicas and for holding the patients until the plasters were dry.

No patients with fractured femurs were received at this hospital direct from Tobruk. Seven patients arrived with the fractured limb immobilized by means of a plaster spica. In every case but one (Case XXVI), the spica had to be removed at the earliest opportunity. In many instances pressure sores had already developed. Frequently attempts had been made to relieve extreme discomfort by splitting the plaster at different sites. In six out of the seven cases the fragments were in unsatisfactory position. While it must be admitted that, from the point of view of immobilization of the fracture, most of these spicas were satisfactory, the experience here has only served to strengthen the opinion already expressed that "for general purposes no better method has yet been devised" for immobilizing a fractured femur during transport than the Thomas splint.

Incidentally, it was of some interest to note that one soldier (Case XVIII) arrived at the hospital with the injured leg tied to a long Liston splint—not, I am glad to say, from an Australian unit. The story of his trip simply does not bear repetition. It is a great pity that the persons responsible were not there to hear it.

TREATMENT.

First-Aid Treatment and Transport to First Surgical Centre.

First-aid treatment and transport to the first surgical centre have already been referred to, and further information is contained in Tables II and III. It is not proposed in this paper to go fully into details of treatment

in the forward battle zones. No special mention will be made of blood transfusions *et cetera*, because such resuscitation therapy, in the early and critical hours after wounding, was in very capable hands and for all practical purposes did not concern this hospital.

Treatment at First Surgical Centre.

In the case of most of the battle casualty gunshot wounds and one or two of the road accident fractures, first surgical centre treatment was carried out either at the nearest casualty clearing station or by a surgical team in a forward area. Seven patients were admitted from surrounding districts to this hospital, which thus became their first surgical centre. Among these patients were two with gunshot wounds and two with the "civilian" type compound fractures (Cases II, V, XVI and XVIII).

The great importance of wide incision of a gunshot wound has in actual fact assumed such prominence as to have become a form of mild surgical hysteria. Naturally the treatment of "civilian" compound fractures should differ in no way from that carried out in civilian practice. So many fractures, not only of the femur, treated in this hospital are of this type that reference to it is not out of place in a paper dealing with war-time surgery.

Treatment of "Civilian" Type of Fracture.

Simple Fractures of the "Civilian" Type.

The treatment of simple fracture of the "civilian" type is fully dealt with later.

Compound Fractures of the "Civilian" Type.

The essential principles in the treatment of compound fractures of the femur of the "civilian" type are precisely the same now as they were in August, 1939.

1. They are surgical emergencies and should be operated upon at the earliest possible opportunity after the admission of the patient to hospital.

2. If this is done within a reasonable time,¹ the fracture, if possible, is converted into a "closed" fracture, even if it is necessary to make counter-incisions to enable the skin to be closed without tension.

3. The closure of the fracture is made both possible and safe by radical enlargement of the wound, and the most elaborate and ruthless excision of all soiled and damaged tissue.

4. Exclusion of catgut or any other form of ligature, except when quite large vessels require ligation. (In actual fact all but the main limb arteries will stop bleeding after the application of a hot pack and a little pressure.)

If this procedure is faithfully carried out, the great majority of such fractures will heal by first intention, and generally behave in much the same manner as simple fractures at the same site. It is true that this procedure is time-consuming, two hours or more not being considered over long when dealing with a femur or tibia and fibula. In this respect it is almost certainly impracticable during the more hectic periods so often the lot of forward surgical units during battle conditions. However, these fractures are occurring at all times, so that it behoves military surgeons to preserve a proper sense of proportion when dealing with them more or less at leisure.

¹ What constitutes "a reasonable time" after injury during which it is safe to close a compound fracture must remain a matter for individual surgical judgement. It is not possible to lay down any time limit. Watson-Jones states that after six or eight hours it is unlikely that infection can be avoided. It must surely depend on many other factors, particularly the amount of soft tissue damage and the amount of contamination from outside sources. If it is decided, because of the time factor or any other reason, that the fracture is an "infected" one, the wound must not be closed. The *débridement* is carried out in exactly the same manner, but the wound is left widely open in order to provide for the freest possible drainage.

Treatment of Compound Fractures due to Gunshot Wounds.

Probably owing to the publicity given to the work of Trueta, Winnett-Orr and others of latter years, very great advances have been made in the treatment of compound fractures due to gunshot wounds. The experience of surgeons in forward units has been almost invariably the same—that no matter how small and insignificant the entry and exit wounds may seem, the modern projectile does tremendous damage to soft tissues, particularly of course to muscles. Generally speaking, the following conditions obtain by the time the soldier is brought to the first surgical centre: (a) There is gross soft tissue damage. (b) Additional contamination by infected clothing may be driven into the depths of the wound by the projectile. (c) One or more pieces of the projectile may be still *in situ*. (d) The soldier may be severely shocked. (e) Many hours may have elapsed since the time of injury.

The stage then is surely set for infection. The surest way to combat it is to prepare for it by providing the freest possible drainage.

Wound Toilet.

If possible, radical enlargement of the wound is performed, together with excision of such damaged and soiled tissues as can reasonably be reached. In addition, multiple incisions, criss-cross if thought necessary, are made through fascial and muscle planes in the region of the wounds. The wounds themselves are then left open and loosely packed, not plugged, with "Vaseline" gauze. Wounds treated at the First Australian Casualty Clearing Station, many of which subsequently reached this hospital, were also frequently impregnated with "Vaseline"—yet another method of keeping open the tissue planes. These wounds did particularly well.

Foreign Bodies in Wounds.

If possible, foreign bodies should be removed. Obviously there are many factors which must influence the surgeon in making his decision on this matter, the more important being (a) the condition of the patient, (b) the size and number of the foreign bodies, (c) their accessibility, (d) whether the services of a radiologist, particularly if he has at his disposal an X-ray localizer, are available (Brook's type, which is generally used in the Australian Imperial Force, has proved very efficient).

It is purely a question of surgical judgement just how much or how little should be done at the first attempt. Small foreign bodies—the size of a pea or smaller—often give no trouble, but large ones nearly always cause persistent infection. In three of the cases in this series large foreign bodies were left *in situ*. For various reasons they were left alone in the hope that the wounds would heal. In Cases III and V a sinus persisted, although in every other way progress was satisfactory. Both these sinuses healed within a few days of the removal of the foreign body and remained healed. In Case IV the wound actually healed and remained healed for several weeks. The foreign body was situated near the posterior aspect of the neck of the femur, so that access may prove difficult. The wound eventually broke down again and a fresh sinus formed. This occurred just before the patient was due to leave for Australia, so that rather than risk his missing the boat, operation for its removal was deferred.

Sulphapyridine Therapy.

The experience at this hospital has been that sulphapyridine therapy, administered in the form of "M & B 693" tablets, has practically eliminated streptococcal wound infections. Surgeons of the last war will no doubt hear

this with envy. None of the compound fractures of the femur admitted to this hospital developed any serious degrees of streptococcal infection.

Table III gives some idea of the amounts of "M & B 693" taken by these soldiers during the first few days after wounding. It will be noted that the treatment was continued after the patient's admission to this hospital. In general, four tablets were given immediately after admission and continued at the rate of two tablets every four hours until: (i) The patient was afebrile and obviously remaining afebrile. (ii) If the patient was not completely afebrile, the wound *et cetera* had obviously settled down and there was no sign of spreading cellulitis or lymphangitis. (iii) The patient was saturated with the drug. In this event, if there was still any anxiety regarding his condition the "M & B 693" was begun again after a short rest.

In several cases the wounds were impregnated with powdered tablets of "M & B 693". The value of this measure is still very much *sub judice*. It certainly does not appear to do any harm. It would, therefore, appear reasonable to continue this practice until, by a suitably controlled series, its efficacy can be definitely established.

Up to this point it must be understood that much that has been written on the subject of compound fractures has been on general principles and is not necessarily the result of experience gained in treating a small series of patients with compound fracture of the femur. Nearly 600 battle casualties, including compound fractures of most of the limb bones, have been treated in this Australian general hospital during the period covered by this series. The treatment generally has been along the lines described. Little has been seen to suggest that the principles discussed should be in any way modified.

TREATMENT AT AN AUSTRALIAN GENERAL HOSPITAL.

Segregation.

At first these patients were admitted under different surgeons. As might be expected, various methods of treatment were used, including plaster spicas and standard forms of traction. Later they were all concentrated into one ward, and all subsequent patients were admitted directly there. During the summer a tented ward was used and proved quite satisfactory (Figure I). It was for various reasons found to be unsuitable when the rains came. The patients were, therefore, moved to a hatted ward (Figure II).

The case for segregation of such fractures under one surgeon has been argued many times before, and it is not intended to discuss the matter here. It should be noted that it was the more difficult fractures due to gunshot wounds that were dispersed in different wards, and that the more consistently satisfactory results, obtained later by the routine method about to be described, were generally, from the outset, on much simpler problems. There can be little doubt also that the men have been very much happier together than in ones and twos, mingling with patients whose stay in hospital may be numbered in days instead of months. It is the same with all "long-stay" patients, as the orthopaedic surgeon knows only too well.

With all the patients in one ward the treatment quickly became standardized. With few exceptions it was as follows: (i) The fractured limb was slung in a Thomas splint bent at the knee (or just above) according to requirements. (ii) Skeletal traction was applied through the tibial crest. (iii) Initial reduction was obtained by manipulation under general anaesthesia. (iv) Position and alignment were checked radiologically at frequent intervals, a portable machine being used. (v) When the patient was due for repatriation a plaster spica was applied.

TABLE I.
A. COMPOUND FRACTURES.
DUE TO GUNSHOT WOUNDS.

Case Number.	Cause.	Type of Fracture.	Résumé of Treatment.	Condition on Discharge.	Shortening. (Inches.)	Comments.	Weeks after Wounding Soldier Repatriated.
<i>Neck of Femur.</i>							
I	Shot at three yards' range with service rifle.	Trans-cervical with minimum comminution. External and vertical rotation and upward displacement of lower fragment.	Reduced on traction table. Single spica applied. Plaster changed for repatriation.	X-ray examination showed union taking place, but slight absorption of neck of femur with minimal <i>coxa vara</i> . Wounds healed.	0.5	Shortening might have been avoided if double spica applied. On the whole, satisfactory result.	10 weeks.
<i>Upper and Middle Thirds of Shaft.</i>							
II	Revolver bullet.	Slightly comminuted, middle third.	Skin traction proved unsatisfactory. At eight weeks two inches short with angulation. Manipulation under general anaesthesia to refracture. Skeletal traction applied through tibial crest. Good position and alignment obtained and maintained. At four and a half months spica applied as a safety measure for repatriation.	Fairly firm union. Position and alignment satisfactory. Wounds healed.	Nil.	Note failure of skin traction. In personal communication soldier states that caliper was fitted on hospital ship and that leg is very satisfactory.	22 weeks (14 weeks after refracture).
III	Machine gun bullet.	Slightly comminuted, middle third.	Skin traction proved unsatisfactory. At four weeks skeletal traction through tibial crest. Spica applied at eight weeks. After foreign body removed. End - to - end contact never established. Spica changed for repatriation.	Good alignment, union progressing but still not firm. Wounds healed.	0.5	Note healing of wound after foreign body removed. Should be satisfactory result.	20 weeks.
IV	Trench mortar fragment.	Comminuted, upper third, involving trochanter.	See case history.	See case history.	1.0	Repatriated in spica. Foreign body still <i>in situ</i> . Slight discharge from sluis.	20 weeks.
V	Revolver bullet.	Transverse, middle third.	Skin traction proved unsatisfactory, then skeletal traction through tibial crest. End-to-end contact never established, but alignment good. Spica applied at nine weeks after operation for removal of foreign body.	Callus, present but union not firm. Wounds healed.	0.5	Result should be satisfactory, with healing of wound after removal of foreign body.	13 weeks.

TABLE I.—Continued.
A. COMPOUND FRACTURES.—Continued.
DUE TO GUNSHOT WOUNDS.—Continued.

Case Number.	Cause.	Type of Fracture.	Résumé of Treatment.	Condition on Discharge.	Shortening. (Inches.)	Comments.	Weeks after Wounding Soldier Repatriated.
<i>Upper and Middle Thirds of Shaft.—Continued.</i>							
VI	Machine gun bullet.	Grossly comminuted, upper third, involving shaft.	See case history.	See case history.	0.75	Alignment satisfactory. Fair result except for ischemia of foot.	19 weeks.
VII	Machine gun bullet.	Oblique, subtrochanteric, high in upper third.	See case history.	See case history.	0.5	Sound union. Fair result except for ischemia of foot.	27 weeks.
VIII	Machine gun bullet.	Oblique, high in upper third.	See case history.	See case history.	Nil.	Union occurring but callus still soft. Position and alignment satisfactory.	Still in hospital.
IX	Trench mortar fragment.	Transverse, lower third.	Skeletal traction through tibial crest. Spica at seven weeks.	Union fairly firm with plentiful callus. Position and alignment satisfactory.	Nil.	Should be satisfactory result.	8 weeks.
X	Machine gun bullet.	Comminuted, lower third.	Skin traction proved unsatisfactory. At six weeks manipulation under general anesthesia to correct two-inch shortening and gross angulation. Skeletal traction through tibial crest and upper third. Good position and alignment obtained and maintained. Spica at 13 weeks.	Fairly sound union. Wounds healed.	Nil.	Personal communication. Galper atted on hospital ship. Should be satisfactory result.	21 weeks.
XI	Machine gun bullet.	Comminuted, lower third, involving knee joint.	Put up at first in spica which was uncomfortable. Condition deteriorated. Fresh spica applied with same result. Pressure sores developed over sacrum. At six weeks full leg plaster substituted. By this time becoming more comfortable.	Plaster removed at 12 weeks and union found to be sound. Only few degrees of movement in knee joint. Wounds healed.	2.0	Note failure of spica to maintain length though there was probably some actual loss of bone. Result of plaster was good, largely on function that is regained in knee joint. Repatriated without splints.	13 weeks.
XII	Machine gun bullet.	Comminuted, supracondylar, involving knee joint.	At first in spica which was unsatisfactory, causing pressure sores over sacrum. Full leg plaster was substituted at six weeks and changed when it became offensive. See case history.	Still in full leg plaster. Upper end of shaft sequestering and protruding through wound which was still grossly infected. See case history.	2.0	Note failure of spica to maintain position or length. This will be a bad result and at time of repatriation looked as if amputation would eventually be necessary. Died.	12 weeks.
XIII	Trench mortar fragment.	Comminuted, lower third.	See case history.	See case history.	0.75	May require amputation.	
XIV	Revolver bullet.	Oblique lower third.					

TABLE I.—Continued.
A. COMPOUND FRACTURES.—Continued.
DUE TO "CIVILIAN" TYPE INJURIES.

Case Number.	Cause.	Type of Fracture.	Résumé of Treatment.	Condition on Discharge.	Shortening. (Inches.)	Comments.	Weeks after Wounding Soldier Repatriated.
XV	Motor cycle accident.	Comminuted, middle third.	Thomas splint with extension through plaster controlling compound fracture of tibia and fibula. Very ill from hemorrhage. Large hematoma evacuated on day of admission. Sepsis untended. Died during amputation four weeks after admission. See case history.	—	—	—	—
XVI	Motor cycle accident.	Transverse comminuted, upper third. Comminuted medial condyle same side.	—	See case history.	0.25	Wounds healed. Fairly firm union. Ready for repatriation.	—
XVII	Motor cycle accident going into action.	Transverse, lower third.	Skeletal traction through tibial crest. Satisfactory position and alignment obtained. Later, end-to-end contact lost and never regained. Alignment quite fair in side-to-side position. Union slow, but began after four months.	Put up in splint for repatriation. Union fair but not firm. Alignment fair. Wounds healed (after secondary suture at 10 weeks).	Nil.	This case was complicated by compound fracture of lower third tibia and fibula of same leg. This was treated in below-knee plaster from the outset. Loss of position in femur due mainly to attempted economy in X-ray films. End result in regard to femur should be fairly satisfactory. One of the few considered safe to repatriate in this way.	23 weeks.
XVIII	Road accident.	Comminuted, supra-condylar, with linear crack extending into knee.	Skin traction proved unsatisfactory. At six weeks manipulation under general anesthesia to correct gross angulation. Skeletal traction through tibial crest applied. Good position and alignment obtained and maintained. At four months spica applied. Union progressing well.	Spica removed shortly before repatriation. Union found to be firm. Few degrees of movement only in knee joint.	Nil.	Ultimate result will depend entirely on function of knee joint. This patient was transported from local "A.R.P." in a long Liston splint.	21 weeks.

B. SIMPLE FRACTURES.

Upper and Middle Thirds of Shaft.

Case Number.	Cause.	Type of Fracture.	Résumé of Treatment.	Condition on Discharge.	Shortening. (Inches.)	Comments.	Weeks after Wounding Soldier Repatriated.
XIX	Motor cycle accident caused by shell explosion.	Comminuted, middle third. Large "butter-fly" fragment.	Skeletal traction through femoral condyles — double abduction. Good position and alignment obtained and maintained. Spica at 10 weeks, by which time union progressing satisfactorily.	Still in spica, excellent position and alignment.	0.5	Traction through femoral condyles begun at casualty clearing station because of trauma of knee joint, suggesting damage to cruciate ligaments. End result will depend entirely on function of knee, which at the time of application of last spica appeared satisfactory.	17 weeks.

TABLE I.—Continued.
B. SIMPLE FRACTURES.—Continued.
Upper and Middle Thirds of Shaft.—Continued.

Case Number.	Cause.	Type of Fracture.	Résumé of Treatment.	Condition on Discharge.	Shortening. (Inches.)	Comments.	Weeks after Wounding Soldier Repatriated.
XX	Road accident.	Transverse, middle third.	Skeletal traction through tibial crest. Several manipulations under general anesthesia required before end-to-end contact of fragments obtained. At 12 weeks wire broke, so spica applied. Skeletal traction through tibial crest with double abduction. Good position and alignment obtained and maintained.	In spica short of ankle bearing. Position and alignment excellent. Union progressing well.	Nil.	This soldier should have been repatriated in a caliper, which was not available. It was not considered safe to send him back to Australia without some support to the fracture. At eight weeks callus is plentiful and position maintained. The case will present a difficult problem necessary within the next month. This type tends to "concertina" in spica.	
XXI	Road accident.	Comminuted, upper third extending to treacher.	Treated at casualty clearing station for one month by skeletal traction through tibial crest. Transferred to this hospital in good position and alignment. Good union obtained. Put up in double abduction in attempt to control scoliosis at site of fractured fourth lumbar vertebra. Died on fourth day from multiple injuries.	—	Nil.	At six weeks, satisfactory callus formation. Case complicated by crush fracture of fourth lumbar vertebra with partial paraplegia.	
XXIII	Fell from third story balcony.	Transverse, middle third.	Skeletal traction through tibial crest in slight flexion and double abduction.	—	—	The most recent case at present in good position and alignment.	
XXIV	Fell from balcony.	Perthrahanteric.		—	Nil.		
<i>Lower Third and Supracondylar Fractures.</i>							
XXV	Motor accident.	Transverse, lower third.	Skeletal traction through tibial crest. Good position obtained and maintained. At 13 weeks spica for repatriation.	Union fair, position and alignment excellent.	Nil.	Complicated by compound fracture of shaft of humerus, in which no union had occurred at time of repatriation. Arm immobilized in full arm plaster cast fixed to chest.	22 weeks.
XXVI	Motor accident.	Transverse, lower third.	Arrived in spica from casualty clearing station, in which he was comfortable. Position and alignment satisfactory—spica changed as required.	In new spica. Union progressing well. Position and alignment had been maintained.	Nil.	The only one of seven patients admitted in a spica which did not have to be removed.	9 weeks.

TABLE 1.—Continued.
B. SIMPLE FRACTURES.—Continued.
Lower Third and Supracondylar Fractures.—Continued.

Case Number.	Cause.	Type of Fracture.	Résumé of Treatment.	Condition on Discharge.	Shortening. (Inches.)	Comments.	Weeks after Wounding Soldier Repatriated.
XXVII	Motor cycle accident.	Transverse, lower third.	Skeletal traction through tibial crest. Good position and alignment obtained and maintained. At 13 weeks immobilization discontinued owing to sound union. Gradual weight bearing begun.	Firm union in excellent position and alignment. Movement of knee gradually improving. Walking with one stick.	Nil.	Complicated by severe petrol burns, both thighs. At 10 weeks skeletal traction to remaining area of granulation tissue starting in lower third of thigh affects knee movement, satisfactory result anticipated.	
XXVIII	Road accident.	Transverse, lower third.	Treated at casualty clearing station for 10 weeks by skeletal traction through tibial crest. Then transferred to this hospital. Callus did not show until 16 weeks. Satisfactory position and alignment maintained from the outset.	—	Nil.	Will be repatriated in a spica. Should be satisfactory result.	
XXIX	Road accident.	Slightly oblique, lower third.	Skeletal traction through tibial crest. Several manipulations under general anaesthesia required before end-to-end contact obtained. At nine weeks after breaking of wire overnight spica applied. Position maintained.	In same spica. Check X-ray examination showed position still maintained. Union progressing, but not firm.	Nil.	Chief interest was difficulty in maintaining end-to-end contact in slightly oblique fracture. Also that four Kirschner wires broke at various times.	14 weeks.
XXX	Road accident.	Transverse, lower third.	Skeletal traction through tibial crest. Good position obtained and maintained. At nine weeks callus plentiful.	—	Nil.	Satisfactory.	
XXXI	Road accident.	Grossly comminuted, supracondylar.	Treated at casualty clearing station for eight weeks by skeletal traction through <i>os calcis</i> , which was necessary owing to multiple abrasions, although fracture was not compound. Except for some posterior angulation of lower fragment position and alignment fairly satisfactory.	—	0.75	In this type of comminuted fracture traction should be maintained until union is firm. He is a British soldier and will be transferred to a British hospital at a convenient date.	
XXXII	Run over by a Bren gun carrier.	Transverse (slightly comminuted), lower third.	Skeletal traction through tibial crest. Good position and alignment obtained and maintained. Callus visible at five weeks.	—	Nil.	Patient admitted to this hospital in enormous spica from axilla to toes on injured side and to above knee on sound side with the fragments in poor position. An excellent result is anticipated.	

TABLE II.
Details of Transport from Field to Base Hospital.¹

Case.	Lay Out.	Transport through Forward Units to Surgical Centre.	Final Journey to this Hospital. Number of Days for Total Journey.
II		Admitted direct to this hospital from camp 15 miles away.	Legs tied together. Quite good trip.
III	13 hours (all night).	Five hours carry to regimental aid post slung over two rifles. Extremely painful. Thomas splint, halter method, at regimental aid post. Trip thence to casualty clearing station good.	Comfortable journey by ambulance train and motor ambulance, but had slight hæmorrhage in train. Four days' trip.
IV	1½ hours.	200 yards carry to road, thence on Bren carrier to regimental aid post. Thomas splint, halter method, at regimental aid post. Thence by ambulance to casualty clearing station. Quite fair trip. Spica at casualty clearing station.	Good in spica. Two days for whole journey.
VI	5½ hours.	Six hours carry to regimental aid post on ground sheet; very little pain. Thomas splint, halter method, at regimental aid post, thence to L.F.A. at Haifa. Good trip.	Halter on for 36 hours. Good trip. No pain. Two days for journey.
VII	34 hours.	Half hour carry to regimental aid post. Thomas splint and halter applied. Thence via Sidon to L.F.A. at Haifa by ambulance; journey only fair. (Staged at Sidon, where transfusion given.)	Halter left on foot for 75 hours without being touched. Does not remember much about the trip. Whole journey took four days.
VIII	Picked up immediately.	Driven by car to Damascus and on operating table within an hour. He sat next to the driver during this trip. After wound toilet (twice), staged journey to base with Thomas splint and halter.	Bad trip in ambulance. Good trip in train. Whole journey took five days.
IX		On stretcher with rifle as splint to main dressing station. Thomas splint, halter method, here. Thence by ambulance to casualty clearing station. Good trip.	Good trip next day. Still in Thomas splint. Staged one night at casualty clearing station.
X	8½ hours.	Two miles to road on stretcher, thence by ambulance to casualty clearing station. Thomas splint with skin traction at casualty clearing station.	To base by ambulance and ambulance train. Latter part of journey painful. Extensions have become loose. Staged over one week for whole journey.
XI	Nil.	Thomas splint at scene of wounding. Bad trip to casualty clearing station. Spica applied.	Good trip by ambulance train.
XIV	Nil.	To main dressing station in utility truck. Thomas splint with halter. Two days journey to Damascus by ambulance, which was bad. Put in spica at Damascus, thence to Nazareth. This part of the trip was by far the worst.	It had been intended to go further on fourth day, but the spica was so uncomfortable that he was admitted to an Australian general hospital at Nazareth. Later transferred to this hospital in spica. Bad trip.

¹ Many of these soldiers had been repatriated before it was decided to write this account. Deficiencies in Tables II and III are due to the fact that all records have been sent to Australia with the patients.

Reduction.

In every case in which the position was not satisfactory an attempt was made to reduce the displacement by manipulation under general anæsthesia. The attempt was repeated if necessary. There are few greater mistakes made in the treatment of fractures of the femur than to imagine that, once the leg is slung and traction is applied, nothing more is required of the surgeon than to hang a few weights on the end of the cord. That many displacements will be corrected in this way there can be no denial, but the reverse is only too true. Where there was no gross comminution, end-to-end contact of the fragments was aimed at. Although obviously to be obtained if possible, complete anatomical contact is not essential. Provided approximately one-third end-to-end contact is established, without angulation in either plane, union should occur and a perfect functional result will be obtained. With gross comminution, the position is different and merits separate discussion.

Subsequent Management.

Immobilization.

The Thomas Splint.—In the majority of cases skeletal traction with the limb in a Thomas splint was used to immobilize the fracture. The Thomas

splints were slung and counterpoised, and have proved, as indeed they always have, extremely satisfactory. Since they were merely being used as a cradle, the size of the ring mattered little. In every case some degree of flexion at the knee was obtained by bending the splints. It is a grave error to immobilize the knee joint for any length of time in full extension—a point which might well be remembered when treating other fractures of the lower limb. In supracondylar fractures it is advisable to bend the splint under the fracture rather than under the knee joint; it is the surest method of defeating the constant tendency to backward bowing in these cases. Only in fractures of the upper third of the femur was it found necessary to sling the other leg as well. Skin traction with only a few pounds weight was then used and proved satisfactory. As a general rule the slings were well padded with wool and the whole limb bandaged onto the splint.

Except in three cases, in which for various reasons traction was through the femoral condyles, the routine site was the tibial crest just below the tuberosity. At first Kirschner wires were used, but owing to the wires being of inferior steel constant trouble was experienced. Many broke while being "strained", frequently necessitating the insertion of another wire. Others broke at most inconvenient times, under the strain of 20 or 25 pounds' traction. When, in addition, the drills began to give trouble, it was decided to use the Steinman transfixion pin, which is certainly easier to manage.

Until now, mainly owing to having seen several disasters due to infection following the use of transfixion pins, I have never used them for any form of skeletal traction. In this series, other than slight tenderness in the region of the pin track and the discharge that cleared up within a few days of the removal of the pin (or wire), there have only been two instances of persistent infection following skeletal traction (Cases VI and VIII). To date it must be admitted that the transfixion pin is much easier to use than the Kirschner wire and appears to be giving very little trouble.

The Plaster Spica.—At first, as soon as considered safe, skin traction was substituted for skeletal traction. This, however, proved to be a delusion and a snare and has now, except for light traction on the sound limb when double abduction is necessary, been entirely abandoned. When union has progressed to the extent that there is little chance of the fragments becoming displaced, the soldier is considered ready for repatriation in a plaster spica.

The spica has already been referred to in the matter of transport. That it is both an orthodox and legitimate method of treating some fractures of the femur is admitted. There are, however, many difficulties that are almost invariably encountered, if the fracture is treated in the spica from the outset. In the first place nobody who is not completely familiar with plaster technique should attempt to treat such fractures in spicas, nor should anyone at all unless reasonable facilities for their application are available. There can be few things more uncomfortable than a bad spica. No Thomas splint, however neglected, can cause a patient quite the same physical and mental distress. Reasonable conditions for the application of a spica to a recent fracture—or for that matter any fracture before some union has occurred—require for the minimum equipment a traction table and a portable X-ray machine. The necessary conditions obtaining, the spica is an excellent method of treating certain of these fractures, particularly of the neck (if nailing is contraindicated), the lower third of the shaft and supracondylar fractures. Great patience and care must be exercised during the initial reduction of the fracture on the traction table, the position of the fragments being checked radiologically until reduction is satisfactory.

Three patients (Cases I, XVI and XXVI) were treated throughout in a spica. There was no alternative in Case I, in which the fracture was through

the neck of the femur. Case XVI was a fracture of the upper third of the shaft which for special reasons (see case report) was treated throughout in a spica. Generally speaking this is an unsuitable method of treating such fractures before some union is established for the following five reasons.

1. The upper fragment is often flexed and abducted, is short and difficult to control, and for this reason frequently cannot be maintained in alignment with the lower fragments, unless by good fortune the fragments lock.

2. Even after locking of the fragments, in order to maintain alignment, the limb must be kept flexed and abducted. This is not only difficult to obtain in the spica, but has the effect of forcing the sacrum against the back of the plaster, where, in spite of adequate padding, pressure sores are prone to develop (Case VIII).

3. No matter how skilful and well trained the plaster-room team, it is impossible to apply a spica so closely that, when the patient is removed from the hip prop, there is not some degree of mobility of the pelvis. Securing the opposite limb in plaster, or even continuing the plaster up to the axilla, does not eliminate this.

4. Wasting of the large muscle bellies at the top of the thigh inevitably takes place after a few days. This, combined with slight mobility of the pelvis, not only allows angulation—particularly posterior bowing—to occur but may allow of major displacements with loss of end-to-end contact and shortening to take place (Case XVI).

5. Without end-to-end contact, as in comminuted fractures, some shortening usually occurs as soon as the limb is released from the traction table, and more so later when, because of wasting *et cetera*, the spica becomes less efficient (Cases IV and VI).

For the same reasons, though to a somewhat less extent, the spica is not the best method of treating fractures of the middle third of the shaft. Fractures of the lower third of the shaft and supracondylar fractures are in a different category. Here there are no great muscle bellies to waste, and if the plaster is well applied and carefully moulded about the knee joint, position is not so readily lost. In Case XXVI spica treatment was adopted throughout and excellent position was maintained. Even in these cases great care is required in the initial reduction to guard against posterior bowing. The plaster is usually applied over a sling which passes under the fracture site to the horizontal member of the traction table. One final word regarding spicas—it is very much easier in every way and with a reasonable chance of maintaining position to apply a good spica to a thin patient, with bony prominences around which the plaster can be carefully and closely moulded, than to a patient with fusiform thighs and a corpulent abdomen.

Maintenance of Position.

In all cases serial X-ray photographs were taken with a portable machine on an average every fortnight, and more frequently in the days immediately following the initial reduction. It is a false and dangerous economy not to make such frequent checkings of position and alignment. All sorts of factors combine to make displacement of the fragments an easy matter, even after the appearance of callus. This is occasionally difficult to detect by clinical examination alone, and weeks of time may be lost if substantial callus has to be broken down to correct some major displacement that has gone unnoticed (Cases II, IV, X and XVIII). It is obviously of very special importance when the fracture is being treated in a plaster spica.

TABLE III.
TREATMENT OF WOUNDS.
A. Gunshot Wounds.

Case.	"M & B" Therapy.	Nature of Wounds and Initial Treatment.	Immobilization.	Became Afebrile.	Progress of Wounds.
I	? Before admission, 36 tablets in three days.	Entry wound, small, just below Poupart's ligament; exit, postero-lateral aspect of thigh, also small. Ordinary dressing before admission. Both were quite clean and were dressed with "Vaseline" gauze.	Spica.	Four days.	Gave no trouble, and when spica changed for repatriation at 10 weeks were completely healed.
II	36 tablets three days after admission.	Entry wound on medial aspect of thigh; exit wound postero-laterally, and rather large. Immediate wound toilet at this hospital.	Thomas splint.	Mildly febrile sixth to tenth days only.	Excellent from beginning. Completely healed in five weeks.
III	100 tablets in nine days begun at casualty clearing station.	Wound toilet at casualty clearing station. Several fragments of bone removed, but one foreign body not located. Entry wound on lateral aspect of thigh; exit wound on inner side.	Thomas splint.	Fifth week.	Wounds healed completely except for persistent sinus from entry wound. Healed rapidly after removal of foreign body at eight weeks.
IV	? Before admission, 24 tablets two days after.	Wound toilet at casualty clearing station. Entry wound on front of upper third of thigh; exit over gluteal fold. Foreign body left <i>in situ</i> , situated behind neck of femur.	Spica, later Thomas splint.	Eighth week.	Exit wound healed early. Some discharge from entry wound persisted for several weeks then stopped. Later broke down, but soldier repatriated before foreign body removed.
V	36 tablets in three days.	Immediate wound toilet at this hospital. Foreign body removed at initial operation.	Thomas splint.	Fifth day.	Small sinus persisted until foreign body removed after nine weeks, when it healed within 10 days.
VI	? Before admission, 48 tablets four days after.	Wound toilet at casualty clearing station. Entry wound in buttock. Entry wound in thigh, exit wound on antero-lateral aspect of thigh, exit wound behind. Wound toilet at Hadda without removing splint.	Thomas splint.	Third week.	Both were clean on arrival at this hospital and healed within three weeks.
VII	? Before admission, 24 tablets two days after.	Entry wound on antero-lateral aspect of thigh, exit wound behind. Wound toilet at Hadda without removing splint.	Thomas splint.	Fourth day.	Entry wound healed in eighth week, exit wound tenth week. Neither gave any trouble and were dressed as required with "Vaseline" gauze.
VIII	100 tablets in 14 days.	Entry wound antero-lateral aspect of upper part of thigh, exit wound immediately behind. First toilet immediately after wounding. Second two days later. (See text.)	Thomas splint.	Thirteenth week; became febrile again later. (See text.)	Formed two gravitational abscesses. (See text.)
IX	24 tablets in two days.	Wound dressed at casualty clearing station. Small foreign body under skin in back of thigh removed. Entry wound in front.	Thomas splint.	Never febrile.	Healed within three weeks.
X	14 tablets in two days.	Dressed again at main dressing station. Wound toilet at casualty clearing station. Exit wound open. Foreign body removed, no exit wound.	Thomas splint.	Seven days.	In 10 weeks wound had completely healed. At no time gave cause for anxiety.
XI	48 tablets in four days.	Wound toilet at casualty clearing station. Both entry and exit wounds on medial and lateral aspects of thigh above knee excised and left open. Put in spica.	Plaster throughout.	?	Completely healed by twelfth week.
XII	Several courses after admission.	No details of initial treatment available. Admitted in spica, which was removed at the fifth week. Entry and exit wounds inner and outer aspects of thigh above knee both grossly septic.	Plaster throughout.	Never.	At 11 weeks, when repatriated in full leg plaster, wounds still grossly septic and lower end of femur projecting through wound on inner side.

TABLE III.—Continued.
TREATMENT OF WOUNDS.—Continued.
A. Gunshot Wounds.—Continued.

Case.	"M & B" Therapy.	Nature of Wounds and Initial Treatment.	Immobilization.	Became Afebrile.	Progress of Wounds.
XIII	Several courses after admission.	Wounded four months before admission. Large open gressy wound over outer aspect of thigh, which was evacuated same day. Wound in thigh and over fractured tibia and fibula no effect in controlling sepsis. Spica similarly merely obstructed drainage. When window cut in spica, wound pointed.	Thomas splint and spica.	Never afebrile.	Formed gravitational abscesses, eventually performed. Patient died of lung complications.
XIV	Many courses before and after admission.	Injured 10 weeks before admission. Wound had been grossly septic from beginning. Wound toilet not done until third day, when foreign body removed. Subsequently formed several gravitational abscesses.	Thomas splint.	Never afebrile.	Further spread of infection towards knee joint is occurring. Being prepared by traustrusions for probable amputation.
B. "Civilian" Type Wounds.					
XV	Accurate details not now available. Had several courses after admission.	Very ill on admission. Large hematoma in thigh, which was evacuated same day. Wound in thigh and over fractured tibia and fibula remained septic throughout.	Thomas splint.	Never afebrile.	Sepsis could not be controlled. Guillotine amputation performed through thigh. Died immediately afterwards.
XVI	48 tablets in four days.	Radical excision of both wounds, with removal of all soiled and bruised tissue. Both flayed with "M & B 693" powder. Wound over knee joint closed completely. Wound over knee joint, from which much skin had been lost and which opened into joint left open.	Spica.	Six days.	Thigh wound healed by first intention. At eight weeks window cut in plaster over knee and guillotine amputation performed. Subsequently dressed with "M & B 693" powder, <i>tulle gras</i> , mercurchrome to edges and covered with a saline pack. Completely healed at 14 weeks.
XVII	? Before admission, 48 tablets in four days after.	Wound toilet at casualty clearing station. Thigh wound, widely excised, dusted with "M & B 693" powder, impregnated with "Vaseline", and left widely open. Wound over fractured tibia and fibula simply dressed with flaying.	Thomas splint, plaster below knee.	Two days.	On admission, wound over thigh was very large, but clean. It was dressed with "Vaseline" gauze at about three-weekly intervals. It healed at about three weeks. At 10 weeks secondary suture completely successful. There was a little discharge from the leg wound under the plaster at the first change, after which it closed.
XVIII	48 tablets in six days.	Wound toilet immediately on admission. Excision and removal of loose fragments of patella. Wound closed with gauze wick drainage.	Thomas splint.	Eleventh day.	Wound remained clean and healed quickly, except for one small sinus, which closed in six weeks.
XXV	Details not available.	Small puncture wound over fracture of lower end of humerus. This had healed. At first Thomas splint, but later changed to Thomas splint. It was found that the hematoma had become infected and much pus was evacuated. Wound had ceased to discharge when plaster changed at 10 weeks.	Plaster cast.	Never afebrile.	No union in humerus had occurred when soldier was repatriated.
XXVII	Nil.	Large petrol burns on both thighs, which were quite clean on admission. Dressed daily with "M & B 693" powder, <i>tulle gras</i> , mercurchrome to the edges, and a saline pack over the wound. At eight weeks pinch grafts to larger wound. At 10 weeks placed daily in saline bath.	Thomas splint.	Never febrile.	Completely healed at 12 weeks, with very little scarring considering the extent of the burn on the same side as the fracture, which required grafting.

Treatment of Wounds.

There is a feeling in some quarters that plaster *per se* exerts some healing influence upon an open or septic wound. I do not subscribe in any way whatever to this view. Wounds heal well under plaster for two main reasons: (a) they are immobilized, (b) they are safe from interference.

A wound adequately immobilized by any other means—to wit, a Thomas splint—and left alone will heal in very much the same manner. Possibly those immobilized under plaster have this advantage, that since the plaster absorbs much of the discharges, it takes longer to become offensive than an ordinary dressing and, in consequence, is changed slightly less frequently.

The treatment of large flesh wounds has rightly become the province of the plastic surgeon, so that no comment is attempted here. Other than wounds which were either grossly septic or were in the nature of sinuses due to retained foreign bodies, in only three cases did they require any special treatment (see Table III).

In Case XVI the wound was immobilized under plaster, and left entirely alone for eight weeks. It was then subjected to intensive treatment along the lines recommended by the plastic surgeons. It healed completely in fourteen weeks, required no skin grafting, and at no stage gave any trouble.

In Case XVII the injuries included a "civilian" type of compound fracture, in which the wound had been widely excised, radical *débridement* had been performed in a most thorough manner, but in which no attempt had been made to close the wound. The limb was immobilized in a Thomas splint, and the wound, which was very large over the outer surface of the middle third of the thigh, was ignored. It gave absolutely no trouble, the dressings being changed at roughly three-weekly intervals. The area of granulation tissue was extensive, but it was epithelializing satisfactorily from the edges. At the end of ten weeks there was no callus showing radiologically at the site of the fracture, so that in preparation for possible surgical interference secondary suture of the wound was performed. This was completely successful, and in point of fact could have been done some weeks before.

In Case XXVII the patient had sustained extensive second and third degree petrol burns on both thighs. These were treated from the beginning by daily dressings (see Table III). At eight weeks pinch grafts were applied to complete healing. At ten weeks, when sufficient union of the fracture had occurred to permit it, the patient was placed in saline baths daily. At twelve weeks the wounds were completely healed. At no time did they give any cause for anxiety.

Except in the cases already mentioned in which foreign bodies had been left *in situ*, and in five other extremely septic wounds, two of which proved fatal, the wounds healed well and remained healed.

Functional Activity.

There are three cardinal principles underlying the treatment of all fractures. Briefly they are: (a) reduction of the fracture and prevention of redisplacement under X-ray control; (b) immobilization which must be complete and without interruption until union is sound; (c) the active exercise of joints and limbs which need not be immobilized.

As far as possible these principles have been faithfully followed. A masseuse visits the ward daily, paying particular attention to the feet of the limbs which are immobilized. The patients are encouraged to move the sound limb as much as possible throughout the day.

Regarding knee movements, no attempt has been made by means of hinged splints to preserve them during the period of absolute immobilization. The amount of movement possible in such circumstances is very limited. It is, in fact, negligible if the fracture is low in the shaft, and complete immobilization is not to be interrupted. It is not worth the risk of prolonging the period of immobilization because of associated movement at the site of fracture, which in the majority of cases will accompany such knee movements and almost certainly cause some delay in union. According to the long

view, the progress towards complete rehabilitation will be greater at the end of six months in the case of a patient who has had union at three months and has been actively moving his knee and bearing weight during the succeeding three months than it would be in a similar case in which five months' immobilization were required, but in which some degree of mobility at the knee joint had been maintained throughout.

The Comminuted Fracture.

There are special problems associated with the treatment of the comminuted fracture that merit detailed consideration. Metallic fragments, travelling at high speed, can shatter a femur into many fragments. Five fractures of this type appear in this series, and there were five other cases in which there has been considerable comminution in the nature of splitting the bone into large fragments in a more or less longitudinal direction (Cases II and XXI).

Case VI is typical of the gross comminution that can be caused by the modern projectile.

Good alignment was obtained and maintained by skeletal traction in a Thomas splint. Actually the limb was about half an inch elongated, a state of affairs which was deliberately maintained in case of eventualities. At ten weeks, with the skiagram showing good callus formation, traction was reduced to ten pounds. Within five days the fragments had concertinaed to the extent of one and a quarter inches, so that the limb was now three-quarters of an inch short. Traction was increased to 30 pounds and the shortening was slowly overcome. At this stage the Kirschner wire broke. Confronted with a comminuted fracture in good alignment, with plenty of callus formation and no shortening, it appeared to me to be the obvious time to apply a spica. This was done on the traction table, and the limbs were of equal length by measurement when the spica was applied. When, five weeks later, a fresh spica was applied for the voyage home, it was found that the limb had again shortened to the extent of three-quarters of an inch.

In actual fact, considering the severity of the injury, this cannot be rated as a very bad result; but it could and should have been avoided. Cases IV, XI and XII were others in which shortening occurred while the limb was immobilized in a spica. The lessons to be learned from these cases are:

1. That spicas are not a satisfactory means of immobilizing a comminuted fracture of the femur in the early stages.
2. That the spica should not be used to immobilize comminuted fractures of the upper third of the femur until union, both clinically and radiologically, is fairly well established.
3. That grossly comminuted fractures will shorten after many weeks of efficient immobilization even though callus be visible radiologically, unless quite considerable traction is maintained.

Just when it is safe to lessen the traction or apply a spica in these cases must remain a matter for individual judgement (Case XXI). Obviously it is preferable to maintain enough traction in a Thomas splint to preserve equality in length. Such traction can be lessened from time to time, while a most careful check is kept on the measurements. Only in this way can similar errors be avoided. When considering these cases from the point of view of readiness for repatriation in a spica, it is better to wait for the next ship rather than to abandon traction prematurely.

Repatriation.

All these patients appear before a medical board and are generally classified "C2" or "D". Either means that they are to be returned to Australia by the first available ship. The problem created by the necessity of providing adequate immobilization for the voyage is often a difficult one. The military

machinery, whereby the patient becomes listed for repatriation, is complex and may take some time. So much so in fact that in several instances it became necessary to decide whether any further immobilization was required at all. However, after consideration of the amount of man-handling required at this end of the trip alone before the patient was even on board the ship, it was usually decided when in any doubt at all to "play safe".

In this series fifteen soldiers have been evacuated in spicas and eight more are shortly to be.

One patient, Case XII, travelled in a full leg plaster, and three travelled without any splints at all. So far as has been ascertained, only one—and that, remembering the innumerable complaints that the patient made daily while in the ward, is doubtful—has given any trouble of any kind. In Case XII the patient was evacuated in a full leg plaster; he had a grossly infected supracondylar fracture. This was purely a question of expediency. Owing to pressure sores another spica was out of the question. In actual fact the patient's leg was very thin and very close moulding about the knee was possible. At least the fracture was rendered painless.

No caliper splints are provided under the Army scale, and the size and shape of the rings of the Thomas splints are such that only in exceptional cases can a Thomas splint be converted into a caliper which will be both comfortable and safe. In Cases II and X the patients had calipers fitted on the hospital ship, and these were apparently satisfactory (personal communication). The necessity of applying spicas for the voyage home in the majority of cases means that at least some of the knees will be stiffer than they usually are in civilian practice. Since they almost invariably regain full function eventually, this is a small penalty to pay for "safety first" measures.

Complications.

Sepsis.

Eighteen compound fractures do not form a large series. Of these, fourteen were due to gunshot wounds, the remainder being ordinary "civilian" type injuries. In five cases (Cases VIII, XII, XIII, XIV and XV) the wounds remained septic for a considerable time, and in two instances (Cases XIII and XV) contributed largely to a fatal result. In Case XIV the patient is, at the time of writing, being prepared by transfusions *et cetera* for amputation, and unless considerable improvement occurs in the state of the wounds within the next week or so this will soon be required as a life-saving measure (see Table III).

As has already been suggested, it is probable that sulphapyridine therapy has contributed very largely to this comparative freedom from serious sepsis. The "lag" period between time of wounding and wound toilet does not appear to influence the subsequent progress of the wound so much as was previously thought to be the case. In Cases III, VI, VII and X the patients all lay out for long periods before being picked up by stretcher bearers, yet in no single instance did their wounds give any cause for anxiety. On the other hand, in Case VIII the patient was picked up immediately after wounding and driven by car straight to Damascus, where, to use his own expression, he was "on the table within an hour"; yet this patient was grossly septic from the beginning. He was operated upon twice within the first two days. It may be presumed that for various reasons it was not possible to perform complete *débridement* on the first occasion.

Unfortunately, in the majority of these cases no records are available as to whether the projectile penetrated the clothing. Most of the soldiers were wearing shorts at the time of wounding, so that it is probable that in some at least of the lower third fractures the clothing was not penetrated.

Three of the worst cases of sepsis occurred in fractures of the lower third of the shaft.

In dealing with such septic wounds the two main problems are local sepsis and gravitational abscesses.

Local Sepsis.—The importance of providing adequate drainage as a prophylaxis against local sepsis was fully realized by surgeons in forward units, and has already been discussed. There is little more that can be done other than to see that such drainage is maintained. Irrigation by means of Carrel-Dakin tubes has been utilized in two cases, but the number is much too small to draw any conclusions.

Gravitational Abscesses.—The formation of gravitational abscesses is one of the most serious problems confronting the surgeon dealing with grossly infected fractures of the femur. Case VIII has already been referred to.

After admission to the Australian general hospital the patient's lower extremities were put up in abduction with a Kirschner wire through the femoral condyle on the injured leg. Since the fracture was high in the upper third of the femur, and the short upper fragment was flexed, abducted and externally rotated, it was necessary to bring the limb into alignment with it. Both the entry and exit wounds were septic and discharging copious amounts of offensive pus. At approximately nine weeks after wounding the exit wound behind had closed and there was only intermittent discharge from the entry wound in the front of the thigh. For some weeks his general condition had alternated between very good and an obviously septic state. During the latter periods he would register evening temperatures up to 102° F. It became obvious that further drainage was necessary and eventually an obvious swelling appeared in the buttock. This was incised, through-and-through drainage being established with the entry wound. His general condition improved immediately, and excellent progress was made for two months.

At five months after wounding he was put up in a spica for repatriation. It was still necessary to maintain flexion of the limb, as, although union was progressing, the callus was still very soft. When the plaster was applied there was some slight infection at the site of the pin hole over the inner femoral condyle—no more than usual. After he had two weeks in plaster, his general condition again began to deteriorate, and he became febrile in the evenings. Eventually he complained of pain in the middle of the thigh. The plaster was removed and an obvious abscess found to have formed in the middle of the inner aspect of the thigh. The pin hole over the medial femoral condyle was discharging fairly profusely, and pressure over the abscess caused a sudden increase of the discharge. The abscess was opened and found to have been caused by pus tracking proximally up the flexed thigh, under the influence of gravity, between the tissue planes. Progress in every way has since been satisfactory.

Such gravitational abscesses are a problem of extreme importance to army surgeons because they are going to be met with again and again in the treatment of infected compound fractures of the femur. Many suggestions have been made as to how they should be dealt with. The spica has been advised because there is then no necessity to raise the foot of the bed to provide counter-traction—in fact, the head of the bed can be raised to promote drainage. (In this event there is, of course, nothing to prevent the pus tracking in the opposite direction down the leg.) Much may be said in its favour, especially for lower third fractures. At the same time the best answer to the problem at the moment appears to be constant vigilance and radical drainage as soon as such abscesses make their appearance. It is of the very greatest importance to remember that, unless especially looked for, such abscesses are almost certain to be missed for the good and simple reason that in most instances the surgeon is deceived by the overflow drainage, which may be quite copious.

Watson-Jones and others advise the "well-leg traction" method of Roger Anderson for the difficult high fractures of the femur. From the point of view of tracking pus it would be ideal, because the legs are flat on the bed, there is no need to raise the foot of the bed, and any flexion of the upper fragment can be overcome by making the patient sit up. Personal experience

with this method, other than some very satisfactory results seen in children, has been confined to two adult patients in civilian practice. In neither was it satisfactory, but it must be admitted that the apparatus was made by the hospital engineer and was still in the experimental stage. There can be no doubt that excellent results should be obtained so far as the fracture is concerned. "Well-leg traction" may indeed be the answer to the problem.

In regard to bacteriology, swabs from the wounds have given a most profuse growth of all usual types of organisms, and have not really been helpful from the point of view of indicating special lines of treatment. In Case XIV hæmolytic streptococci were plentiful, so a fresh course of sulphapyridine therapy was instituted. So far it is too early to say whether this has been of any use.

Blood transfusions have been given in four cases (Cases VI, VIII, XIII and XIV) for the purpose of improving the patients' general condition. In each instance considerable improvement was noted.

In Case XIV, three weeks ago, the red cell count was 3,290,000 per cubic millimetre and the hæmoglobin value was 64% (51% Sahli). After two blood transfusions, each approximately 600 cubic centimetres, the red cell count is 4,010,000 per cubic millimetre and the hæmoglobin value 80% (64% Sahli). The patient's general condition, appetite *et cetera* have also improved very considerably.

Peroneal Palsy with Foot-Drop.

Peroneal palsy with foot-drop occurred twice (Cases IV and VIII). Both patients were in poor general condition when it occurred, with considerable wasting of muscles. In Case IV the foot-drop occurred gradually over a period of one week in spite of all efforts to stop it (see case report). Both these palsies should recover in time; but in Case VIII it has been a considerable worry, the patient from the very beginning having developed pressure sores under the slightest provocation.

Renal Colic.

One patient (Case III) had two attacks of renal colic, which were fairly severe and associated with transient hæmaturia. It is possible that the attacks were due to genuine "recumbency calculi", as the soldier had been in bed for about three months before they occurred. No stones were passed and no calculi could be seen in the skiagram.

Ischæmia of the Foot.

Ischæmia of the foot occurred twice (Cases VI and VII) and has already been discussed.

Tetanus.

No case of tetanus has occurred in this hospital. The routine prophylactic dose of antitoxin was 3,000 international units. When this amount had not been given the deficiency was made up immediately after the patient's admission to hospital. In addition, all these soldiers had had the routine tetanus toxoid injections immediately after enlistment (two injections of one cubic centimetre at six-week intervals, followed by one similar injection every twelve months).

Gas Gangrene.

No proved case of gas gangrene has occurred in this hospital. In Case XIV a skiagram taken while the patient was at another Australian

general hospital showed several large bubbles of gas in the tissues. *Clostridium welchii* was present in cultures from the wound. In spite of the fact that this soldier was an extremely ill man, an appreciation of the fact that gas in the tissues does not necessarily mean gas gangrene, even when *Clostridium welchii* is also present in the same tissues, is responsible for the fact that this soldier still has his leg and may even yet not lose it. In point of fact, such large bubbles of gas were possibly introduced from without. At the same time it is extremely important to remember that an anaerobic cellulitis, due to organisms, some of which are gas-forming—including *Clostridium welchii*—can and does occur. It is not associated with necrosis of muscle, is generally confined to the cellular tissues, may not cause the same toxic prostration, has not the typical "mousy" odour of true gas gangrene, and rarely necessitates amputation of the limb.

The reason for the freedom from tetanus and gas gangrene in nearly 600 battle casualties is outside the scope of this paper. It should be recorded, however, that in the case of gas gangrene particularly, no little credit must go to the surgeons in forward units, on whom the responsibility of most of the immediate treatment devolved.

Associated Injuries.

Table IV sets out in detail other injuries sustained by these soldiers at the time that their femurs were fractured. In all cases these injuries were dealt with along orthodox lines. A fracture of the tibia and fibula in the same leg occurred twice. In both instances this was controlled by a plaster cast and the whole limb was put up in a Thomas splint.

TABLE IV.

Associated Injuries.

Case.	Injuries.	Remarks.
XV	Compound fracture of tibia and fibula of same limb.	Died immediately after amputation.
XVI	Compound comminuted fracture of medial femoral condyle, same side, opening into knee joint.	Few small pieces of bone removed. Wound left alone under plaster. Healed well.
XVII	Compound fracture of tibia and fibula of same limb. Very minute punctured wound which was simply dressed. Treated in below-knee plaster cast, and slung in the Thomas splint.	Very small amount of discharge from wound, which soon stopped. No union at five months, when soldier repatriated.
XVIII	Slightly comminuted fracture of patella, really same injury as the supracondylar fracture.	Few small pieces removed at initial wound toilet. Healed well. Knee still stiff when soldier repatriated.
XXII	Fracture-dislocation of fourth lumbar vertebra. Fracture of body and ramus of mandible. Partial paraplegia with bladder symptoms. The bladder symptoms have disappeared and the paraplegia is recovering slowly.	Gross scoliosis had occurred at site of fractured spine. For some weeks this soldier was desperately ill and nothing could be done for his jaw or back. Jaw now wired. Double abduction of both legs has greatly improved scoliosis. No further treatment of spine yet possible owing to pressure sores.
XXIII	Fracture-dislocation of first cuneiform in same foot, and comminuted fracture of patella of same limb. Multiple fractures of mandible. Fractured nasal bone. Fracture of orbital plate of right side.	Died on fourth day.
XXIV	Linear fracture of upper and lower pubic ramus without displacement.	In double abduction, and quite comfortable.
XXV	Compound fracture of lower third humerus. Large hematoma became infected and much pus evacuated when first plaster changed.	No union when soldier repatriated. Wound closed, and still in plaster.
XXVII	Colles's fractures of both forearms. Petrol burns on both thighs.	Treated in usual forearm plaster casts and excellent results obtained. Burns as in Table III.
XXIX	Fracture of upper ends of both radius and ulna. Comminution of radial head. Considerable angulation of ulna.	Radial head removed. Open reduction of ulna, with much improvement in position. Temporary palsy of posterior interosseous nerve.
XXXII	? Intraabdominal injury. Operation at forward unit, laparotomy.	No ruptured viscus, but much bruising of bladder wall found. Wound healed normally.

NOTE.—It is interesting that no fractures due to gunshot wounds were multiple, whereas all "civilian" compound fractures were.

Mortality.

Three patients in this series died. Two deaths followed "civilian" accidents, and one, enemy action. Case XIII presented many interesting features and was the only one among fourteen cases of compound fracture due to gunshot wound in which the patient died.

He came to us from a British hospital some four months after being wounded at Tobruk. This case has already been referred to in some detail. After amputation the abscesses drained freely until the stump began to granulate over, which it did in a most satisfactory manner. As this occurred, drainage became less free and the patient's general condition became worse. Further incisions were therefore necessary in the thigh. Unfortunately he was already complaining of pain in the chest, and shortly showed all the signs, first of embolic pneumonia, then of pus in the pleural cavity. Post-mortem examination showed an almost gangrenous lung and a very large empyema.

In Case XV, a despatch rider sustained compound fractures of both the femur and tibia, *plus* the fibula, in the same leg. He was always very ill and grossly septic. His condition did not improve even after transfusions, and he died on the table immediately following a guillotine amputation through the thigh.

In Case XXIII the patient died on the fourth day from the effect of multiple injuries sustained in the fall from a balcony.

Prognosis.

It is not possible at this juncture, especially when the patients have passed completely out of our hands in varying stages of union, to make an accurate forecast of the ultimate end-results. Table I sets out the state of affairs as regards the fracture, length of limb, state of union *et cetera*, either at the time of repatriation or, in the case of those still in hospital, of writing.

It will be noted that very few of the patients have any great degree of shortening. When repatriated, the patient in Case XII looked as if he would lose his leg. Other than that, union should occur in satisfactory position in the remainder. The question of stiff knee joints has already been discussed. In four cases the knee joint was involved in the fracture (Cases XI, XII, XVI and XVIII). That some degree of useful movement will occur in these knees is fairly certain. Whether this movement will be too painful for the joint to be used remains to be seen. In all probability it will not be.

It is confidently anticipated that the peroneal palsies will recover. It is anticipated, with equal confidence, that there is a great deal of trouble in store for the patients in Cases VI and VII in regard to their feet. A great deal more work has to be done before the patient in Case VIII will walk again. Not only will his knee be extremely stiff but the hip is becoming fixed in flexion, probably by scar tissue due to prolonged sepsis in this region. It is not possible to deal with it until union of the fracture becomes sound.

Taking the series as a whole the results are expected to be fairly satisfactory.

CASE REPORTS.

Case IV.

The patient was wounded by a trench mortar fragment in the upper third of the thigh; the exit wound was behind in the gluteal fold. He lay out for one and a half hours, and was carried 200 yards to the road, thence on Bren carrier to a regimental aid post, where a Thomas splint was applied with traction by the halter method. He had a comfortable trip from there to the casualty clearing station. Wound toilet was performed at the casualty clearing station, but two foreign bodies (one large) situated posterior to the neck of the femur were not removed. The limb was immobilized in a plaster spica and he was transferred four days later to this hospital. X-ray examination revealed a comminuted fracture of the upper third of the femur from the trochanter to five inches down the shaft. Three weeks later a fresh spica was applied. This was not comfortable and the patient complained of pain over the sacral area. Six weeks after his admission to hospital the spica was removed and the limb was found to be two and a half inches short. Under general anaesthesia some callus, which had formed, was

broken down by manipulation, skeletal traction through the femoral condyles was applied and the legs were put up in double abduction with hip and knee joints flexed. Pressure sores were present over the sacrum, and these had been caused by the spica. The wounds were healing well and the soldier became afebrile in the eighth week. His general condition was still poor, but improved rapidly after transfusion of one pint of blood. Fair position and good alignment were obtained and maintained for some weeks. He gradually developed a peroneal palsy, which waxed and waned over a period of one week before becoming complete. Shortening had by this time been reduced less than half an inch and callus was showing in the skiagram. In the fourteenth week the wire pulled through into the suprapatellar pouch. A spica was then applied. Union was not sound, but was progressing well, and the legs were of equal length on the traction table. When a fresh spica was applied for repatriation four weeks later, it was found that nearly one inch of shortening had occurred while the patient was immobilized in the spica. The wounds were healed completely by the tenth week and were still closed when the spica was applied at fourteen weeks. During immobilization in this spica, the entry wound broke down. Just at this stage the patient's name was placed on the nominal roll for repatriation by hospital ship, so that rather than risk his being unfit to travel, operation for removal of the foreign body was deferred.

Case VI.

The patient was wounded by a machine gun bullet, and lay out for five and a half hours. He was then picked up and endured a six-hour carry on a ground sheet to the regimental aid post over very rough ground. A Thomas splint was applied at the regimental aid post, with traction by the halter method. His trip to the surgical centre at Haifa was good. Wound toilet was performed there without removal of the splint or loosening of the halter. He was later evacuated by train to this hospital, where he arrived two days after being wounded. On admission, both wounds were reasonably clean, entry being in the thigh and exit in the buttock. Although he had not complained of pain in the foot, when the halter was removed a large area of local gangrene was found where the bandage had crossed the dorsum of the foot. The foot and ankle were swollen, and movement and sensation were absent below the ankle. X-ray examination revealed a grossly comminuted fracture of the whole of the upper third of the femur. Satisfactory alignment was obtained and maintained by skeletal traction through the tibial crest, with the limb slung in a Thomas splint; actually half an inch elongation was present. The wounds did well and healed within three weeks, by which time the patient was afebrile. A condition of ischæmia developed in the foot with contractions of the toes. The foot was supported in a club-foot shoe and mobilized daily by a masseuse. At ten weeks, traction was reduced to 10 pounds (skin traction). Within five days shortening had occurred to the extent of one and a quarter inches, so that the limb was now three-quarters of an inch short. Traction was increased to 30 pounds (skeletal traction), and the shortening overcome. At this stage the wire broke. A spica was then applied, and the limbs were of equal length on the traction table. Five weeks later a fresh spica was applied for repatriation. It was then found that three-quarters of an inch of shortening had again occurred. Up to the time of repatriation, other than the healing of the pressure sore on the dorsum, no appreciable improvement had occurred in the condition of the foot.

Case VII.

The patient was wounded by a machine gun bullet and lay out for thirty-four hours. After a half-hour carry to a regimental aid post a Thomas splint was applied, with extensions by the halter method. He was very shocked, and the journey to the hospital was staged at various points over four days. He was given a transfusion at an advanced resuscitation unit attached to a field ambulance. He was then taken to Haifa, where wound toilet was performed without removal of the limb from the splint. He was then sent by train to this hospital, where he arrived four days after being wounded. On admission he was still very shocked and remembered little of the journey. The entry wound was situated on the antero-lateral aspect of the thigh and the exit wound behind. Both were clean. The halter, which had been left untouched for seventy-five hours, was removed and a gangrenous area was found on the dorsum of the foot where the bandage had crossed it. The foot was swollen and anæsthetic, and no voluntary movement or sensation was present below the ankle. X-ray examination revealed a subtrochanteric fracture, slightly oblique, in fairly good position. The limb was up in a Thomas splint with skeletal traction through the tibial crest, and except for some overlap, due to flexion of the upper fragment, fair position and alignment were obtained and maintained. Both wounds were healed by the tenth week, by which time union had progressed fairly satisfactorily. A spica was therefore applied, ending just above the ankle so that treatment of the foot might continue. Before this soldier

was repatriated sufficient union had occurred to enable him to travel without splints. Very little improvement in the foot, other than the healing of the pressure sore, had occurred up to this time, twenty-seven weeks after wounding.

Case VIII.

The patient was wounded by a machine gun bullet which entered in front of the thigh just below Poupart's ligament; the exit wound was immediately behind. He himself managed to climb into a truck, where he sat beside the driver during an hour's drive to Damascus. He was operated on immediately, and again two days later. No details of what was done are now available. From Damascus to this hospital the journey was staged over four days, with the limb immobilized in a Thomas splint. On admission both wounds were grossly septic, and his condition was only fair. X-ray examination revealed a slightly oblique fracture through the upper third of the femur with the short upper fragment flexed, abducted and externally rotated. He was at first put in a Thomas splint, with the limb flexed and abducted at the hip and with skeletal traction through the *os calcis*. He developed pressure sores over the heel and a peroneal palsy. The position of the fracture remained unsatisfactory. During the third week traction was changed to the femoral condyles, and double abduction was used. Heavy traction was applied, up to 50 pounds. Owing to the obliquity of the fracture, even after two-inch distraction was obtained, the proximal fragment was still flexed and in front of the distal fragment. In the fifth week the exit wound had closed. In an endeavour to improve the position, the fragments were manipulated under general anaesthesia. Fair position and alignment were obtained but subsequently lost. During the manipulation a considerable quantity of pus was expressed through the entry wound, which had been discharging very slightly for some days previously. A transfusion of one pint of blood was then given for his general condition, which improved considerably. In the seventh week the fragments were again manipulated under general anaesthesia, and end-to-end contact was established. This has been maintained. In the eleventh week his general condition, which had varied considerably from time to time, was again "septic", with a high evening temperature. The entry wound was practically closed, with very little discharge. A swelling then appeared in the buttock, just above the gluteal fold. This was opened and through-and-through drainage established with the entry wound. His condition improved immediately. The anterior wound healed completely and a small sinus behind persisted for some weeks. Callus was present at five months. At six months, all wounds being healed, a spica was applied. At this stage the knee was very stiff. There was slight infection at both pin holes and the callus was still quite soft. It was hoped that he would be repatriated by the next ship. Some bowing occurred at the fracture site, and after the spica had been on for two weeks his general condition again deteriorated. He had an evening temperature and complained of pain both over the sacrum and in the middle of the thigh. The spica was therefore removed. Pressure sores were present over the sacrum, in spite of double thickness padding. A painful swelling was present in the middle of the outer aspect of the thigh, and pressure over it showed that it communicated with the medial pin hole over the condyle. This gravitational abscess was incised and has since been irrigated every four hours with eusol by means of a Carrel-Dakin tube. It is now healing and his general condition is again excellent. It was hoped, after the spica was removed, that traction would not be necessary, but gross anterior bowing occurred at the site of the fracture. Skeletal traction through the tibial crest was instituted, and with 30 pounds' traction position and alignment were regained within a few hours and have been maintained, ten pounds only being used.

Note: Troublesome pressure sores have developed under the slightest provocation over vulnerable areas in this soldier, and have been a constant source of worry.

Case XIII.

The patient was wounded at Tobruk four months before admission to this hospital. He had sustained a compound fracture of the lower third of the femur, and the wound had apparently been septic throughout. He had required many anaesthetics for dressings, one attempted sequestrectomy (which had not been successful) and several transfusions. His general condition on admission was poor, and there was a large open wound on the outer side of the thigh discharging copious amounts of offensive pus. Sequestrectomy was successfully performed, but sepsis persisted. He was uncomfortable in the Thomas splint, so a spica was applied. This quickly became offensive. A window was therefore cut over the wound and freer drainage allowed. Granulation tissue shortly pouted through the wound, and the spica was therefore removed and a Thomas splint reapplied. His general condition was poor, and eventually it became necessary to amputate his leg. This was done seven weeks after his admission to hospital. He was prepared for the anaesthetic by a transfusion, and a second transfusion was given during the operation. As an immediate preliminary, the femoral artery was ligated low in Scarpa's

triangle. As soon as the fascia was incised, thick pus was encountered. This communicated with the fracture in the lower third of the leg. The artery was ligated and a guillotine amputation performed. A second swelling on the outer side of the thigh, immediately below the anterior-superior iliac spine, also communicated with the fracture. Drainage was very free and it was thought unnecessary to incise this *in situ*. Skin traction was applied to the flaps. His general condition again improved after operation. The stump was dressed two weeks later under gas anaesthesia and was already granulating well. Drainage was still free. His condition again began to deteriorate and drainage from the abscess on the outer aspect of the thigh was less free. It was therefore opened and a stab incision was made posteriorly to promote through-and-through drainage. Irrigation of all the incisions which intercommunicated was instituted by means of Carrel-Dakin tubes. The day after this was done, he complained of pain in the chest, which he said had been present for some days. Clinical examination at this stage disclosed a small area of dullness in the left base and a friction rub. Later he developed all signs of embolic pneumonia and pus in the pleural cavity. His condition rapidly deteriorated and he died twelve weeks after admission and seven months after being wounded. At post-mortem examination the left lung was nearly gangrenous, there was a large empyema, and the stump was clean.

Case XIV.

The patient was injured in the lower third of the thigh by a revolver bullet which entered the lateral aspect of the thigh and left lower down on the medial aspect. The wound was dressed at the time of injury. An operation for removal of the foreign body and excision of the wound was not done until the third day. By this time he was febrile in the evening, his temperature rising up to 103° F. In the second week a spica was applied which, however, was not satisfactory owing to profuse discharge. According to the notes of the British hospital: "Pus found to be collecting owing to posture. Incision enlarged proximally for four inches." In other words, a gravitational abscess had formed. The spica was removed and traction on a Braun's frame substituted. He had one transfusion and was then transferred to another Australian general hospital, where he arrived one month after being wounded. He was treated at that hospital, where an X-ray examination shortly after admission showed gas to be present in the tissues. In spite of a few *Clostridium welchii* being present in cultures from the wound, the gas was obviously not due to true gas gangrene. He was given blood transfusions, and further incisions were made into gravitational abscesses. He was transferred to this hospital in the twelfth week. He was put in a spica for transfer, and his condition on arrival was very poor. The spica was offensive and was removed the next day. A further spread of pus had occurred and another incision was required in the thigh a few inches short of the gluteal fold. The wounds are being irrigated with eusol by means of Carrel-Dakin tubes. He has had two further blood transfusions, and his red cell count is still in the region of four million per cubic millimetre, with a haemoglobin value of 80%. X-ray examination shows an oblique fracture of the lower third of the femur. No union is present. At the moment there is swelling about the knee joint and pus is present in the suprapatellar pouch. This has been aspirated, and is being irrigated with eusol. It is possible that an amputation will be required, for which he is being prepared by further transfusions.

Case XVI.

The patient was injured in a motor cycle accident and sustained a compound fracture of the upper third of the femur (slightly comminuted with a small "butterfly fragment") and a comminuted fracture of the medial femoral condyle on the same side, with a large wound which opened into the knee joint. He was placed on the floor of a utility truck and driven some twenty miles to this hospital. He lost a considerable amount of blood, had a most dreadful journey, and was fairly severely shocked on arrival. No attempt had been made at immobilizing the leg. A Thomas splint was applied where he lay in the truck, and he was carried to the ward. Anti-shock measures were instituted and he made a fairly rapid recovery. He was taken to the theatre three hours after admission. The wound on the outer aspect of the upper part of the thigh was enlarged and a most careful and radical *débridement* performed. The wound was impregnated with "M & B 693" powder and closed completely. The wound over the medial side of the knee joint was large, much skin had been avulsed together with most of the capsule and synovial membrane on the inner side of the joint, and the joint was wide open. Careful *débridement* was performed, but there was no possibility of closing the wound owing to loss of skin. It was dusted with "M & B 693" powder and dressed with "Vaseline" gauze. The problem of immobilization was difficult. Traction from below the knee was not considered advisable owing to the loss of part of the joint capsule. Traction through the femoral condyles meant that the pin would emerge through an open wound. It was therefore decided to attempt to treat this

patient in a plaster spica. Satisfactory reduction was obtained on the traction table, and a spica applied, the opposite leg being included as far as the knee. Subsequent X-ray examination showed that position had been lost, the proximal fragment was still flexed, and end-to-end contact was not maintained. Two weeks later the plaster was removed. The upper wound had healed by first intention. The lower wound was absolutely clean, covered by healthy granulations, but still oozing a small amount of synovial fluid. It was dressed as before. A further attempt at reduction was made on the traction table and after many failures the fragments locked. The spica was applied as before with the leg in slight flexion. This time position was maintained and had not been lost during the fourteen weeks before his plaster was removed. Frequent check X-ray examinations have been made and have shown excellent position and alignment with end-to-end contact of the fragments. Callus is present and at fourteen weeks quite good union has occurred. The limb is about one-quarter of an inch short, owing to the slight comminution of the fragments. At eight weeks a window was cut over the inner side of the knee. The wound was healing in a most satisfactory manner and epithelializing from the edges. It was then dressed with "M & B 693" powder and *tulle gras*, mercurochrome was applied to the edges and the whole was covered with a saline pack. It was completely healed in fourteen weeks. The patient is being repatriated in a weight-bearing single spica, extending to just above the ankle.

SUMMARY.

A series of thirty-two fractures treated in an Australian general hospital between May, 1941, and January, 1942, is reviewed. Particular attention has been paid to the following points:

1. Equipment.
2. The problem of transport from field to hospital.
3. The fact that many of these fractures are actually "civilian" type injuries, and should be treated as such.
4. Special problems relating to the initial treatment of compound fractures due to gunshot wounds.
5. Routine treatment at the Australian general hospital.
6. The place of the plaster spica both in transport and treatment of fractured femurs.
7. The treatment of wounds associated with compound fractures.
8. Functional activity during recumbency.
9. Problems associated with repatriation.
10. The comminuted fracture.
11. Sepsis, particularly the gravitational abscess.

Several case histories have been given in detail where they illustrate particular problems or difficulties in treatment.

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SCAR DISABILITIES OF WOUNDED HANDS.¹

By MAJOR B. K. RANK,

Surgeon-in-Charge, Australian Imperial Force Facio-Maxillary and Plastic Surgery Unit.

Of 270 patients admitted to the Australian Imperial Force "Facio-Maxillary and Plastic Surgery" Unit during nine months in the Middle East, 10% were referred for plastic treatment following wounds of the hand. Methods used for civilian injuries were applied. These are described not for the sake of detail, which will always vary with the individuality and experience of a surgeon, but for the sake of the principles involved and to stress the importance of their full application to war wounds.

Even a small wound of the hand may tragically lower a man's military efficiency and his subsequent earning capacity as a civilian. A large amount of pensionable post-war morbidity will be due to wounds of the hand. It is our duty as surgeons to restore, as far as is possible, the function of any wounded hand. The only true criterion of success is the normal hand. Treatment can be regarded as complete only when the result obtained is as near this optimum as the initial destruction of hand tissue will allow. We know that secondary disabilities too easily arise from delayed or inadequate treatment. We must know, too, that a result cannot be good if treatment is left incomplete.

The function of the hand depends on the integrated and free movement of small joints. The final result in all types of hand wound is always dictated by the condition of these joints or the extent of their disability at the end of treatment. While it is recognized that most war wounds of the hand are composite, this paper is concerned primarily with the scars of healed soft tissue wounds. At once it must be emphasized that a scar which in any way embarrasses the function of a joint is a potential cause of secondary and irreparable changes in that joint. Recognition of this fact is the basis of the correct and timely management of scar disabilities of the hand.

POINTS IN THE EARLIER MANAGEMENT.

Before details of hand scars and their management are discussed, some points in the earlier management of hand wounds must be indicated in their relationship to scar formation and its effects.

Early Healing.

To minimize granulation and its replacement by fibrosis, the earliest possible healing of any soft tissue wound is required. This involves the full application of all that is known in the prevention and control of infection, reinfection and cross-infection, so as to allow uninterrupted secondary intention healing to ensue or successful skin grafting to be performed. Although the vascular soft tissues of the hand heal quickly, a small scar, if crossing a flexure line or fixed to tendon, may cause a disproportionately large disability. Palliative grafts are indicated in hand wounds for areas much smaller than would call for grafting on other areas of the body. Whenever the size of a wound suggests that appreciable time may be saved by skin

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grafting, this should be done, provided that the wound is in a proper state of preparation. "Pinch" or "split-skin" grafts can be used freely, for though the ultimate result may not be ideal, they can always be replaced later by a more suitable type of graft which may not be applicable to unhealed wounds.



FIGURE IIA.



FIGURE IIB.

Figures IIA and IIB show typical scar disability of the healed "hand grenade" type of wound. The pictures show maximal extension of the fingers. Case 214.¹ Photograph taken on December 27, 1941. The hand grenade injury was on October 15, 1941. This is the same case as that illustrated in Figure 1.



FIGURE IIIA.



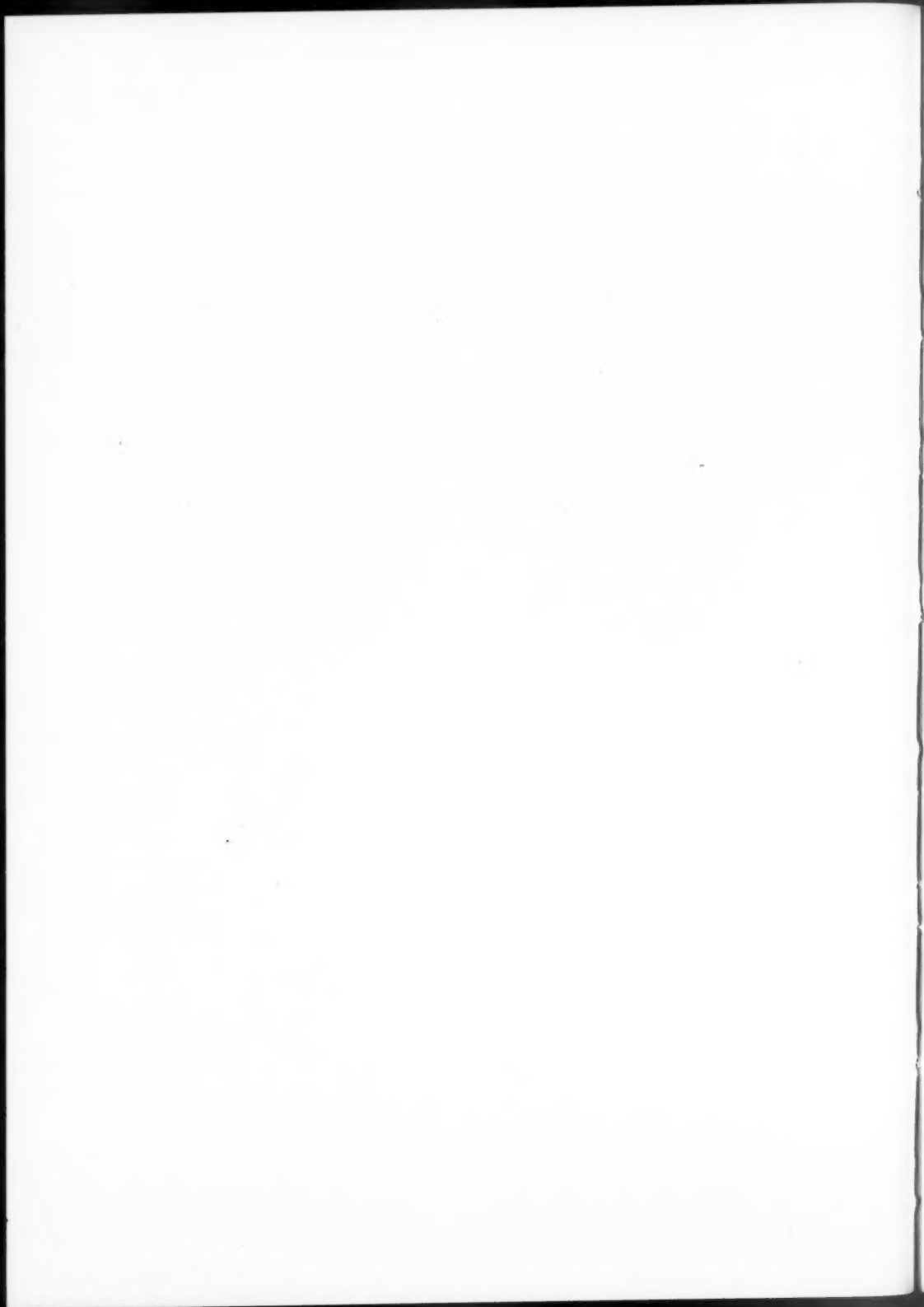
FIGURE IIIB.

Figures IIIA and IIIB show typical scar disability of the healed "hand grenade" type of wound. The pictures show maximal extension of the fingers. Case 251.¹ Photograph taken December 20, 1941. The initial injury was due to an accidental "puff bomb" explosion on November 16, 1941.

¹ This case is followed in later figures.



FIGURE I. Case 214. A typical "hand grenade" type wound of the hand. This sketch was made ten days after the initial injury—a hand grenade explosion—when the hand was taken out of plaster. The hand had been treated by an early *débridement* and completion of amputation of grossly mutilated fingers. Note the flap from the amputated middle finger. Such flaps seldom unite primarily with the locally damaged tissues, but their retention is most important (as applies to all tissues), for they are of great value in subsequent plastic procedures. This will be noted in later photographs of the progress of this hand. Primary treatment by wound excision *et cetera* should be as conservative for hand wounds as for face wounds.



Early Function.

Early function is an important corollary to early healing. Absolute immobilization of the whole or part of the hand may be indicated by any degree of gross or unlocalized sepsis or for associated bony injuries, but this



FIGURE IVA.



FIGURE IVB.

Figures IVA and IVB show typical scar disability of the healed "hand grenade" type of wound. The pictures show maximal extension of the fingers. Case 240. Photograph taken on December 2, 1941. The initial injury by a mortar bomb occurred on September 22, 1941.

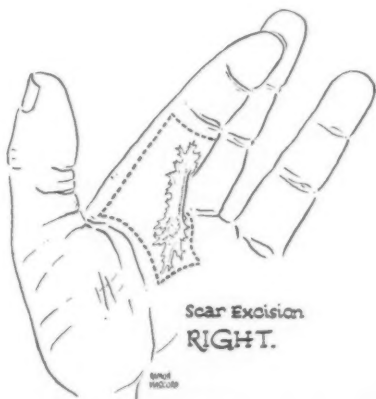


FIGURE VA.



FIGURE VB.

Figures VA and VB illustrate points in the technique of scar excision and Wolfe graft replacement. Scar excision. Edges must be placed so that any potential scar about the edge of the graft cannot reproduce the original scar disability.

need be only of such degree and duration as specifically indicated. Immobilization should be replaced at the earliest safe opportunity by treatment compatible with maximum function. A régime of baths, light dressings and assisted movements has big advantages for hand wounds. The variations in function noted in hands with similar wounds can usually be explained by the varying periods of previous immobilization, which unhappily cannot always be avoided.

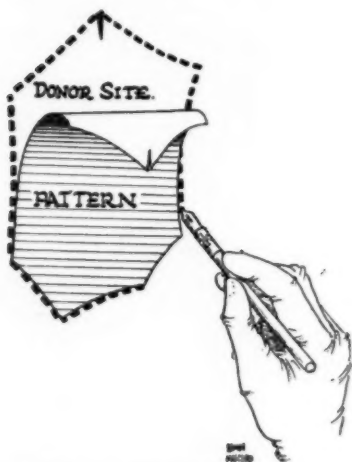


FIGURE VIA. Preparing the graft. Use of pattern and skin markings to outline the graft on the donor site. Note the mark at the upper angle to correspond with the slit in the pattern so that the graft can always be correctly orientated.



FIGURE VIB. Preparing the graft. Dissecting the graft, first stage. Note the skin retraction.



FIGURE VIC. Preparing the graft. Dissecting the graft, second stage. Traction is made with the left hand and the graft dissected off with a sharp scalpel in a plane to include no fat.

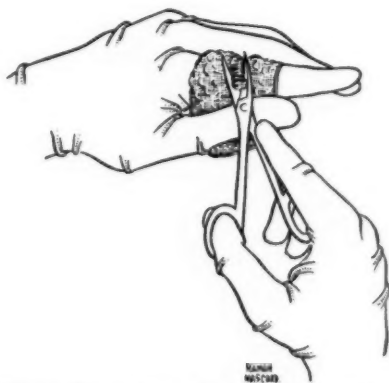


FIGURE VID. Preparing the graft. Trimming the graft of any particles of fat which may inadvertently have been included by the dissection. Note the method of holding the graft.

Figures VIA, VIB, VIC and VID illustrate further points in the technique of scar excision and Wolfe graft replacement.

Physiotherapy for Recently Healed Wounds.

Although physiotherapy has a definite place in the treatment of scar disabilities, it can easily be misapplied. Apart from early shrinkage, softening is part of the normal behaviour of scar tissue as resolution proceeds. Most scars soften in time. Physiotherapy can help or hinder this process of softening, which normally occurs more rapidly in more vascular tissues. Friction massage hastens softening and helps mobilization or freeing of the skin scar from deep scar. On the other hand, scar tissue does not stretch and any attempt to stretch the scar by passive or forced active movement of the appropriate joint is to be strongly deprecated. Forced movements hinder resolution of scar tissue and set up a reactive fibrosis, which produces a "woody" condition of the scar. For these unyielding scars which so often produce flexion deformities, surgery is indicated.

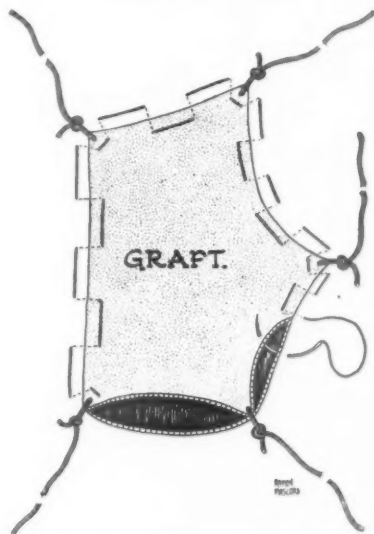


FIGURE VII. Illustrates the last stage in the technique of scar excision and Wolfe graft replacement.

Although joints should be relieved of any scar embarrassment as early as possible, it is important that operation should not be undertaken in the presence of latent sepsis. As a safeguard, therefore, all recently healed areas should be subjected to a course of provocative massage.

Again, recognizing the composite nature of most hand wounds, I propose to discuss the principles of managing scar disabilities with reference to two special types of war injury of the hand: (a) the "hand grenade" type of wound, (b) "through-and-through" type of wound (gunshot wound).

THE "HAND GRENADE" TYPE OF WOUND.

Wounds produced by unthrown "hand grenades" or by detonators characteristically show varying degrees of mutilation of the fingers and palm. One or more fingers are usually in part or completely destroyed by the explosion, or their amputation may be necessary in even a most conservative primary operative treatment. Despite the early horrifying appearance of

these hands (see Figure I), there is often relatively little bony injury in the hand remnant, and under adequate treatment the soft tissues heal quickly.

The healed hand remnant typically shows a varying amount of scarring on the volar aspects of palm, finger stumps or fingers (see Figures IIA, IIB, IIIA, IIIB, IVA and IVB). Scar is usually maximal about the distal palm



FIGURE VIIIA. At completion of operation. On the right is the area of superficial scar excised. Compare this with the area of the graft inserted.



FIGURE VIIIB. At first dressing: the mould with overtied sutures has not yet been removed.



FIGURE VIIIC. After removal of the mould, before sutures are taken out. Complete take of the graft. On the left is the mould, made to fit exactly the contour of the area.



FIGURE VIIID. After three weeks, when pressure dressings are discontinued.

and proximal finger region, and produces various flexion deformities most marked at the metacarpo-phalangeal joints. When fingers have been amputated at these joints, the scar produced by what is usually secondary intention healing of the site causes flexion adduction deformities of the neighbouring fingers (Figures IIA, IIB, IIIA, IIIB, IVA and IVB). It has

often been noticed that when amputation of a finger has included the excision of a metacarpal head, which may have been necessitated by the extent of the initial injury, these secondary disabilities of the fingers on either side are exaggerated. They take up positions out of their normal alignment, and there is a weakening of the grip, even though these fingers may not themselves have been injured. Disruption of the transverse carpal ligament increases this disability. The function of such a hand remnant is limited not only by the scarring and the deformities it produces but also by varying degrees of joint stiffness. Joint stiffness is due to previous immobilization and embarrassment by scar. To these effects the metacarpo-phalangeal joints seem prone.

A hand in which these scars are left untreated, will suffer from functional disabilities far in excess of those created by the original injury and actual tissue loss. If the necessary treatment is unduly delayed, secondary change in and about the joints will render any surgical attack on a cutaneous scar quite unsuccessful in restoring the function of the remnant of the hand.



FIGURE IXA. At completion of operation, scar excision and Wolfe graft replacement, showing the graft *in situ*.



FIGURE IXB. Two weeks later. Complete take of graft. Sutures have all been removed.

Treatment.

The object of treatment is early total excision of the scar and its replacement by skin, like in kind and amount to that which was lost.

A full-thickness (Wolfe) skin graft, correctly used, is the best substitute for palmar or finger skin. It does not contract and maintains permanently an excellent texture. It must be used only on surgical wounds such as are created by a scar excision. Operation must be carried out only with a clear view of its objective. It is quite useless merely to replace a scar by just such another scar. There is no set operation. Every case is to be regarded as a problem of design and technique all its own, and satisfactory results are obtained only by due attention to all the finesse of detail. The guiding principles are noted.

Scar Excision.—This is done in an avascular field created by a tourniquet. It must be as complete as the essential structure will allow and include both skin and deep scar. This means a meticulous dissection to avoid such structures as digital nerves and tendon sheaths. Only when the deep scar is adequately excised is the real defect made manifest and the true skin deficiency revealed as an area much greater than the area of a superficial scar excised. The edges of the excision should be so placed and arranged (see

Figures VA and VB) that any possible scar about the edge of the graft does not reproduce in any part of the original scar disability. This may mean removal of some normal skin in order, for example, to avoid such a scar as a front mid-line vertical scar on a finger. Only better scars in better places are permissible.

Hæmostasis.—After removal of the tourniquet some time and care must be spent in establishing absolute hæmostasis. Any hæmatoma which may



FIGURE XIA.



FIGURE XIC.



FIGURE XIB.

Gunshot wound of the hand. Case 128. Figures XIA, XIB and XIC show the typical healed result of a "through" wound of the hand. There was shortening of the middle metacarpal due to bone loss, and disruption of the extensor tendon of the middle finger, and its proximal end was adherent to the dorsal scar. Other limitation due to joint stiffness.

subsequently collect beneath the graft spells failure. It is undesirable to use any more catgut (fine, "000") than absolutely essential for bleeding which cannot be controlled by the pressure of hot packs or forceps compression.

The Graft.—The graft is cut accurately to an exact pattern of the defect made with silver paper. Its tension, when respread, is then correct for maximal vascular reception on which the effective "mass take" of the graft depends. Pattern and graft should each be orientated by appropriate markings, as whole skin, when cut, is extremely elastic and it may be difficult to orientate the graft correctly (see Figures VIA, VIB, VIC and VID). The graft is carefully dissected and no fat whatever is included. A suitable



FIGURE X. Coloured photograph of a Wolfe graft taken at its first dressing, ten days after operation.

non-hairy donor site is chosen according to the size requirements; the inner aspect of the arm and the region of groin are good donor sites which can be closed by direct suture or a split skin graft, depending on their size and shape. The graft is sutured as shown (see Figure VII), anchoring sutures being used at the key points where the direction of the edge changes and a continuous mattress stitch round the whole circumference of the graft. Absolute approximation, edge to edge, of graft and skin edge is required to avoid peripheral scar. Eyeless needles and fine non-capillary silk (Deknatel) are used.



FIGURE XIIA.



FIGURE XIIc.

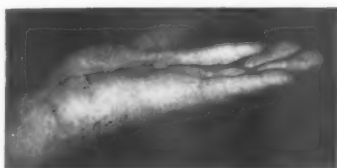


FIGURE XIIb.

Gunshot wound of the hand. Case 128. Figures XIIA, XIIb and XIIc show the result after operation (scar excision, tendon repair and its separation from the fracture site by a flap of fascia) and functional exercises.

Pressure Fixation.—The dressing should be regarded as an important part of the operation. Firm even pressure and absolute fixation are essential. Depending on the site and contour of the area, pressure fixation may be obtained in many ways, all of which are effective. The anchoring sutures may be tied over a mould of dental composition, which is made as an impression of the recipient area before the graft is sutured in place. Similarly, a moulded paraffin-flavine wool pack or marine sponge may be used. Each is supplemented by a crêpe bandage, with free use of "Mastisol". A suitable plaster or splint ensures immobilization of the part.

After-Care.—The peripheral circulation must be watched; but if the dressing has been applied at the correct and even pressure, the circulation will not be embarrassed. Minor grades of œdema and engorgement respond to elevation.



FIGURE XIIIa.



FIGURE XIIIb.

Figures XIIIa and XIIIb illustrate direct flap attachments after scar excision and tendon freeing or repair. Case 123. Gunshot wound of the hand. Figure XIIIa: Four months after wound, at completion of operation—scar excision, extensor tendon repair and direct abdominal flap attachment, with a split skin graft to the donor site. Figure XIIIb: Final result—good extensor function of middle finger and no adherent scar disability.



FIGURE XIVa.



FIGURE XIVb.



FIGURE XIVc.

Figures XIVa, XIVb, and XIVc illustrate direct flap attachments, after scar excision and tendon freeing and repair. Case 184. Mortar bomb wound, with fracture of fifth metacarpal bone and extensor tendons to fourth and fifth fingers severed. Figure XIVa: Abdominal attachment two weeks after operation—scar excision, tendon repair and flap attachment. The tendons were enclosed in a split layer of fat. Operation was three months after the injury. Figure XIVb: At same time. Shows the mobility of the hand while attached and the donor site completely healed by a primary split skin graft. Figure XIVc: Result. Good extensor function of the fourth finger, but with incomplete extension of the fifth finger due to adherent scar from an area of secondary intention healing at the edge of the flap. This case demonstrates the importance of scar elimination. At a further operation to reduce the flap and to eliminate this scar by a local flap operation, it was demonstrated that the tendon repair had been satisfactory and the extensor disability was due to the scar. Good improvement was obtained.

The primary dressing is left undisturbed for ten to fourteen days, when the pressure fixation is carefully removed and all the skin sutures are removed. There is never any doubt about a good take of pink skin. One must not be confused by surface desquamation, which usually starts about this



FIGURE XVA.



FIGURE XVC.



FIGURE XVB.

Figures XVA, XVB, and XVC illustrate direct flap attachments, after scar excision and tendon freeing or repair. Case 196. Gunshot wound. Figure XVA: Three months after wound dense scar adherent to flexor tendons at the wrist, with finger contraction in flexion. Most of the transverse carpal ligament was missing. Figure XVB: Abdominal attachment after scar excision and tendon freeing. Much improved finger extension was obtained by physiotherapy, which was previously ineffective. There was some residual tendon contracture with peri-articular changes. Figure XVC shows the mobility of the hand while attached. Physiotherapy can be applied. The donor site is healed by a split skin graft.

time. The edges and any moist blebs are painted with mercurochrome. The graft is then covered with *tulle gras*; a pressure dressing of a saline solution and wool pack and a crêpe bandage are then reapplied. This dressing is done every day or every second day to allow of gentle and graduated movements; but pressure must always be reapplied until three weeks have elapsed from

the day of graft. These grafts acquire an early blood supply, but a late lymphatic balance; and some oedema may cause delayed separation of the graft if the pressure is removed too soon. Small pin-head ulcers which



FIGURE XVIA. "Hand in pocket" type flap. At the first operation an extensive burn scar adherent to tendons was excised. The flap was designed to the width of the defect and attached to the hand after the abdomen had been closed by direct suture. This photograph was taken immediately before detachment, three weeks after the first operation. Patient had been having baths and finger exercises.



FIGURE XVIB. Healed result on the abdomen. The central line is the closure at the first operation. The crescentic ends are the suture lines made at the second operation after trimming off the redundant ends of the flap.



FIGURE XVIC.



FIGURE XVID.

Figures XVIC and XVID show result on the hand. Though there was a good dorsum to the hand there was little improvement in function because of gross and long-standing stiffness of all finger joints. The hand was burnt six months before the flap attachment.

sometimes appear on the surface of the graft must be carefully watched for and painted with mercurochrome. These ulcers represent low-grade infection

in a tissue of much lowered vitality, and they may spread in a serpiginous manner if neglected, to cause disappointing delayed loss of graft. After three weeks the dressing can be abandoned, light massage with lanoline commenced and more intensive physiotherapy continued. The result of the graft can be good only if the technique receives all the necessary care. The result of the operation can be good only if it is done before joint changes are established. These conditions satisfied, encouraging results for the degree of mutilation often presented are obtained (see Figures VIIIa, VIIIb, VIIIc, VIIIb, IXa, IXb, and X).

"THROUGH-AND-THROUGH" TYPE WOUNDS OF THE HAND.

"Through-and-through" type wounds of the hand are typified by self-inflicted gunshot wounds. Fractured metacarpals and tendon damage are the outstanding features of these wounds. The latter usually affects more the extensor than the flexor tendons.¹ Though the remaining soft tissue



FIGURE XVII. "Z-plastic" rearrangement of a webbed scar. The central limb of the "Z" incision is along the crest of the web. After the flaps—two equilateral triangles—have been lifted, the deep scar must be excised before the transposition of the flaps.

damage is proportionally small, it is important because the resulting scar tissue is usually intimately adherent to tendons which may or may not be severed.

Concerning the relation of dorsal scar to tendon disability it is noted that: (a) At operation it is often found that the tendons are not completely severed, but that skin, tendon and possibly bone callus are all united in a mass of scar tissue. (b) Any attempt at tendon freeing or repair which does not take into account the skin and deep scar is doomed. The original condition of adherent scar and tendon is merely recreated.

The typical functional result of the healed "through" wound (Figures XIa, XIb, XIc, XIIa, XIIb and XIIc) is a limitation of finger function due in part to tendon damage and scar and in part to joint stiffness, especially of the metacarpophalangeal joint. The immobilization required for these wounds is usually much longer than indicated for the "grenade" type injuries, so that joint stiffness is more marked.

¹ We are concerned here with tendon injuries in their more intimate relationships with scar disabilities. Flexor tendon damage when present is not characteristically associated with local scar disability; but it vitally influences a prognosis and the plan of management. The ease of the amputation operation, however, should never be allowed to influence a surgical decision concerning the management of a wounded hand; amputation can always be done later if indicated.

Treatment.

For Small Adherent Scars on the Dorsum of the Hand Associated with Tendon Fixation or Damage.—A tourniquet is used and subcutaneous saline injection about the scar delineates the scar adhesion and makes dissection easier. Superficial and deep scars are excised and the tendon or its ends are freed. If tendon repair is necessary, Bunnell type silk stitches are used. An attempt is always made to wrap the site of any tendon repair in fat or fascia. A flap of fascia is obtained from the dorsum of the hand, in which case extension of the incision is necessary. The skin is resutured or rearranged by a local plastic procedure, so that there is no tension on the important part of the suture line, and no potential scar formation along the line of the tendon. First intention healing is essential. If there is any doubt whatever about exact hæmostasis, a fine twisted silkworm gut drain is left *in situ* for twenty-four hours. A firm dressing is used.



FIGURE XVIIIa.



FIGURE XVIIIb.



FIGURE XVIIIc.

Painful adherent scar of thumb. Figure XVIIIa: Scar of healed gunshot wound (four months previously) had sequestered. It was decided that sepsis was quiescent by X-ray examination and after two weeks' provocative massage. Figure XVIIIb: Attachment to abdomen was carried out with local anæsthesia. Figure XVIIIc: Detachment from the abdomen after two weeks. Photograph was taken one month after the detachment. There was a good soft fat pad over the site of the old tendon scar. The patient was relieved of symptoms, and the operation had enabled retention of the whole thumb, most important even though the terminal joint had only minimal function. (Amputation had been considered in this case.)

For Large Scar Areas on the Dorsum of the Hand Associated with Tendon Fixation or Damage.—In these cases direct resuture or rearrangement cannot be carried out without undue tension, which invites wound breakdown. The scar and tendons are dealt with as above, and the raw area left by the scar excision is covered by a direct flap of skin and fat at the same operation. In most cases a direct abdominal flap can be used. This must be correctly designed according to the principles laid down by Gillies, with respect to the size and location of the defect, its proportions, the patient's comfort during attachment, and so that a minimum of raw area is left exposed. To avoid any wide exposure of raw area the donor site is covered with a split skin graft. This is done after the flap is raised and before its attachment to the hand. A raw area is always a potential source of infection, and it is an important principle that whenever possible it should be covered with a skin graft forthwith. If this can be done, the chances of infection are considerably reduced, and there is then no valid objection to the performance of the flap operation and tendon repair at the same time. This combined procedure has

been carried out many times without regret (see Figures XIIIa, XIIIb, XIVa, XIVb, XIVc, XVa, Xvb and Xvc).

At times it has been found possible to split the fat of the flap so as to enclose a tendon repair, and in these cases results have been satisfactory.

Where a large area of the central dorsum of the hand is denuded, with tendon exposure, it may be necessary to use the "hand-in-pocket" type of flap (see Figures XVIa, XVIb, XVIc and XIVd). This has a double attachment to the abdomen, and thus a good blood supply is assured. The donor area is closed by direct suture, before the hand is attached.

To prevent a hematoma collecting beneath the flap, twisted silkworm gut drains are used, and firm pressure is conveniently maintained by "Lastonet". The attachment is left for two to three weeks, when the flap is detached and its unfinished edge set in. The defect on the abdominal wall can then be closed by a straight suture line. Abdominal attachment is not incompatible with fixation or physiotherapy if either is indicated. The graft on the donor area is "taken down" in five to seven days, and, after a week, baths can be commenced.

A well designed flap over the site of an extensor tendon repair can produce an excellent result, with no superficial scar over the critical site to become adherent again (see Figures XIIIa, XIIIb, XIVa, XIVb, XIVc, XVa, Xvb and Xvc).

OTHER TYPES OF SCAR DISABILITIES OF WOUNDED HANDS.

Webbed Scars.—Webbed scars or bands which inhibit full finger abduction can usually be eliminated by a standard "Z-plastic" rearrangement (see Figure XVII). After the flaps are lifted the deep scar is excised before the rearrangement. Two potentially equal and opposite scar tension lines are produced in a direction in which any subsequent contraction produces no embarrassment.

In some cases it may be preferable to use a full-thickness graft after scar excision, as previously described.

Painful Scars Adherent to Bone.—These often occur on the fingers. They produce distressing symptoms for which patients have asked amputation. They can be well treated by scar excision and its replacement by a flap of skin and fat, either as a direct flap or by the "finger-in-pocket" method (see Figures XVIIIa, XVIIIb and XVIIIc).

Burn Scar Disabilities.—These are mentioned only to point out that much of the horrible aftermath of burnt hands can be prevented by early functional preparation for skin grafting, even though the graft may be palliative, later to be replaced by a more suitable type of graft. It was the results of grossly burnt hands in airmen, treated by coagulation, sometimes misapplied, which precipitated the reactionary school against the tannic acid treatment of burns. For severely burnt hands there is no doubt that a saline bath régime best prepares for early reception of Nature's own dressing of skin, and so prevents undue fibrosis. Where there are denuded tendons a direct abdominal flap may be indicated as an early procedure.

The delayed treatment of the residual disability of burn scars follows the principles already enunciated for other scars. Here, too, we are up against the bugbear of periarticular changes which so easily and so early arise. The only reply to this is early epithelialization, by grafting if necessary, so that early movement and restoration of function can be achieved.

There is still much to be unravelled concerning the more effective treatment of certain traumatic lesions of the hand. In this war, now that we are unfortunately confronted with an abundance of appropriate clinical

material, our opportunity and surgical duty are clear. Any possibility of better tendon repair or of better prevention and elimination of scar disabilities merits full consideration. To this end we cannot overlook fullest application of the principles of plastic surgery.

SUMMARY.

1. The importance of early relief of scar disabilities of the hand is emphasized—that is, before joint changes are established.

2. The part of early wound healing, early function and correct use of physiotherapy in preventing and minimizing scar disabilities of the hand is stated.

3. The "hand grenade" type of injury is described and used as a basis to describe the principles of an effective scar excision and replacement by a full-thickness skin graft.


4. A "through" type of hand wound is described in so far as scar effects are concerned. The principles of effective treatment by (a) scar excision and rearrangement for small scars and (b) scar excision and direct flap replacement for large scars are set out.

5. Other types of scar disability and their treatment are indicated—namely, web scars, adherent scars of fingers and burn scars.

6. A plea is made for the full application of plastic surgery to obtain better results from all hand wounds.

ACKNOWLEDGEMENTS.

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ACTINOMYCOSIS OF THE URINARY SYSTEM.¹

By S. S. GARDINER,
Newcastle, New South Wales.

WITH A SUPPLEMENTARY ARTICLE ON AN ASSOCIATED INFECTION OF THE LIVER.

By D. A. WELSH,
Emeritus Professor of Pathology, University of Sydney.

THE study of actinomycosis of the urinary system is the more interesting in view of the fact that in this field one is exploring, if not altogether *terra nova*, at least to a very great extent *terra incognita*.

A complete review of the literature on actinomycosis of the urinary system is manifestly impossible, partly because of the great difficulty in obtaining the reports of all cases which have been published and also because of the incomplete records published by some writers, and finally on account of the diversity of opinion concerning the use of the term actinomycosis.

The literature on this subject was first reviewed in English by Garceau⁽¹⁾ in 1909, though ten cases⁽²⁻¹¹⁾ were omitted probably because the records were not available. The literature has been reviewed in later years by Nicaise⁽¹²⁾ and also by Rosenstein.⁽¹³⁾

In the first case of actinomycosis ever observed in man the left kidney was involved. This condition was noted in 1845 by von Langenbeck,⁽¹⁴⁾ and was reported by James Israel in 1878. Four fistulae which developed in the left lumbar region discharged moderate quantities of thin malodorous pus which contained numerous yellow actinomyces granules. The bodies of the lower thoracic and lumbar vertebrae were carious, and in the body of the first lumbar vertebra there was a cavity, the size of a walnut, which contained actinomycotic pus and a sequestrum in the process of exfoliation.

Israel⁽¹⁵⁾ has reported a case of his own in detail.

The patient, a female, aged thirty-nine years, the mother of seven children, had never been seriously ill until she met with an accident which was apparently related to and in his opinion was probably the exciting cause of the "primary" lesion which developed in the left lateral wall of the thorax. The patient died about eleven months after receiving the injury. Chronic pyaemia developed, and Israel was able to obtain actinomyces granules from one of the subcutaneous abscesses which developed and thereby established the correct diagnosis of her illness before death.

Although the traumatic genesis in this case was commented upon by the author, comparatively little or no mention at all is made in modern textbooks on the relationship between trauma and the development of certain definitely recognized actinomycotic lesions, an observation which is of paramount importance in view of the various compensation acts now in force in most civilized countries of the world.

At autopsy multiple actinomycotic abscesses were found in the left lung, spleen, liver, kidneys, in the submucosal tissue of the small intestine and in the subcutaneous tissues. The kidneys were moderately enlarged, very pale, and in the cortex many abscesses were found which were arranged in groups and varied in size from a millet

¹ Accepted for publication on March 16, 1942. In the present issue only the first portion of this paper is published. The second portion, to include S. S. Gardiner's case reports and Professor D. A. Welsh's contribution, will appear in a subsequent issue.

seed to a lentil and contained actinomyces granules. In the medullary substance they were completely absent. The larger abscesses were formed by confluence of the smaller ones and had an irregular outline, while others were connected by narrow channels with peripherally located smaller abscesses. As a result of microscopic examination, Israel concluded in this case of pyæmic actinomycosis that the organism passed into the lymphatic vessels surrounding the primary focus of infection, and was subsequently carried to distant organs and tissues by the blood stream. He found actinomyces colonies in the capillary vessels of the glomeruli and also in the urinary tubules.

The same author in 1901⁽¹⁶⁾ reported the first case of "primary" actinomycosis of the kidney, the initial symptom of which was painless hæmaturia.

The patient, a male, aged thirty-three years, who had very carious molar teeth, suffered from intermittent attacks of hæmaturia over a period of seven years and complained of dull pain in the left lumbar region after severe exertion. An exploratory incision had been made in the left renal region by another surgeon five years before the patient consulted Israel, and no abnormality had been detected in the renal pelvis. The upper portion of the kidney was not thoroughly examined on account of difficulty of access. About three and a half years after this operation a sinus formed in the region of the operation wound. Israel found actinomyces granules in the purulent discharge of the sinus and also in the urine. Left nephrectomy was performed with some difficulty. The pelvis of the kidney was found to be occupied by a calcareous mass, about the size of a plum. An actinomycotic tumour, the size of a small apple, was found occupying the upper half of the enlarged kidney, which was surrounded on its upper and lateral aspects by a capsule as white as cartilage and about one centimetre in thickness.

In Kleinschmidt's⁽¹⁷⁾ case the kidney was not enlarged and on section showed an actinomycotic lesion, the shape of a wedge, with its apex lying toward the renal pelvis, which involved the greater portion of the lower half of the kidney, but did not extend to its lower extremity. This wedge-shaped lesion, indicative of hæmatogenous invasion, was bounded by renal tissue which showed only a slight cellular reaction on microscopic examination. At the extreme end of the lower pole a few small actinomycotic nodules were found in the renal cortex. The patient was apparently well eight years later.

PRIMARY RENAL ACTINOMYCOSIS.

No useful purpose would be served by presenting an epitomized description of all the other reported cases in available literature.

A number of authors have criticized Israel's use of the term "primary renal actinomycosis" and have substituted various other terms such as "isolated renal actinomycosis", "actinomycosis limited to the kidney" *et cetera*, and have described under these amended titles lesions which are not strictly "primary" in the sense in which Israel really intended the word to be used.

Israel⁽¹⁸⁾ explained that the descriptive title "primary renal actinomycosis" was used by him, in the same sense as the term "primary renal tuberculosis" was used, to denote that form of renal tuberculosis in which the history of the illness of the patient and clinical examination failed to establish the existence of an older tuberculous lesion which might be regarded as the source of infection. He further explains that, although no actinomycotic focus of infection capable of dissemination is found, it cannot be proved that there was not at some earlier time a lesion in some other part of the body which healed spontaneously. "As a matter of fact", he writes, "such an earlier focus must be assumed as a necessary postulate for the understanding of the pathogenesis of renal actinomycosis just as a similar assumption must be made in cases of primary renal tuberculosis. Neither actinomyces nor tubercle bacilli can infect the kidney by way of the blood stream without having first penetrated the inner or outer surface of the body, i.e. without having entered the body either through the mucous

membrane of the respiratory or alimentary tract or through the external skin." He further states that, after such penetration however, the organism usually, if not always, produces a lesion at the point of entrance or directly enters the lymphatic vessels of that region. These lesions may be so inconsequential and cause so little disturbance in the way of symptoms that they may heal without having revealed their presence, and their recovery may be so complete that they do not even leave a trace which is clinically determinable at the time the actinomycotic lesion in the kidney is discovered.

In available literature eight cases which can be designated "primary renal actinomycosis" have been recorded. These cases have been reported by Israel,⁽¹⁶⁾ Kleinschmidt,⁽¹⁷⁾ Kellock,⁽¹⁹⁾ Kretschmer and Hibbs,⁽²⁰⁾ Kunitz,⁽²¹⁾ (also reported by Neumann),⁽²²⁾ Racic,⁽²³⁾ Schneider,⁽²⁴⁾ and Stanton.⁽²⁵⁾

Bevan⁽²⁶⁾ mentioned a case observed by his colleague Lewis, whose patient at autopsy was found to have extensive actinomycotic involvement of the kidney; the record does not indicate whether the infection was primary or secondary.

Kellock's original article is not yet available to me. At a meeting of the Royal Society of Medicine held early in 1913, he mentioned a case of renal actinomycosis which occurred in a young woman who had a large movable renal tumour. Pyuria and pyrexia were present. The kidney, which was considered on clinical examination to be tuberculous, was removed and on subsequent examination was found to be the site of an actinomycotic lesion.

Five of the patients suffering from apparently primary renal actinomycosis were males, three were females. Six were of adult age and two were children, one aged five years, the other ten years. In four cases the left kidney was affected, in three the right, and in one case the brief account available does not state which kidney was affected.

In one patient the renal lesion apparently developed consequent upon a fall from a swing. In another the lesion may have developed consequent upon operative trauma caused during the removal of a calculus from the upper end of the ureter three weeks previously, at which time the kidney had a smooth surface, was apparently free from pathological changes, and was freely movable. It was partly decapsulated, and nephropexy was performed immediately after the removal of the calculus.

In the other cases definite signs or symptoms indicating a renal condition were present. Two of the patients who suffered from intermittent attacks of renal colic for periods of six and seven years respectively, also had a calculus in the pelvis of the kidney. In five cases red blood cells had been found in the urine at least on one occasion. In two cases the clinical diagnosis was recorded as a renal tumour, in one case calculous pyonephrosis, and in another, with acute onset, cystitis and pyelonephritis. In only one case was a correct diagnosis made previous to operation.

In all cases in which a pyelogram was obtained and in those in which cystoscopy was performed, except in one case, the cystoscopic examination did not reveal the presence of an associated lesion in the bladder and the pyelograms led to inaccurate conclusions. In the case in which actinomyces granules were found in the urine, "the mucous membrane of the bladder was normal except in the region of the ureteral orifice, which was red and congested; within this red background there were three dark red round spots. In the periphery of this reddened zone there were rather large, whitish masses which were adherent to the mucous membrane of the bladder." Apparently the signs in the bladder disappeared after nephrectomy was performed.

In five cases the operation record distinctly states that the operation was performed "with difficulty". One patient was apparently well shortly after

nephrectomy was performed, and of the remainder all except two were apparently enjoying good health eleven months, eighteen months, three years, eight years and eleven years after operation.

One patient died four days after operation as the result of bilateral bronchopneumonia, and in one case in which no operation had been performed autopsy also revealed the presence of bilateral pulmonary tuberculosis.

SECONDARY RENAL ACTINOMYCOSIS.

A number of writers have pointed out that the origin of infection in "secondary renal actinomycosis" cannot always be determined with certainty. In some cases the kidney appears to become infected by direct spread of the infection from an apparently primary focus in the intestinal tract; in other cases the infection extends upward through paranephric and perinephric tissues to the thorax without producing an actinomycotic lesion in the kidney.

The case reported by McLaughlin and Page⁽²⁷⁾ is typical of those conditions in which actinomycotic infection in the lower thoracic region on the right side is the first evidence of direct extension of infection from the region of the appendix. In such conditions a fistula may be found originating apparently in an area of infection in the neighbourhood of the lower end of the caecum, and leading upward anterior or posterior to the kidney and behind the liver, causing infection in one or both of these organs and finally penetrating the diaphragm and infecting the pleura and lung, eventually forming an abscess or sinuses in the wall of the thorax.

In other cases fibrous indurated adhesions, actinomycomata and abscesses are formed in the region of the kidney, destruction of muscle and bone and venous thrombosis may occur, and eventually fistulae may develop in the anterior abdominal wall, lumbar, inguinal, gluteal or thigh regions. The destruction of muscle may extend upward to the costal margin, in a posterior direction to the vertebrae, anteriorly to the *symphysis pubis*.

In at least one case of retroperitoneal actinomycosis in which the kidney was involved, the anterior surfaces of the vertebrae and also portions of the ilium were destroyed as the result of osteomyelitic infection. Retroperitoneal dissemination of infection may be combined with intraperitoneal extension of infection; and abscesses *et cetera* may develop and eventually lead to erosion and perforation of the intestine, urinary bladder or abdominal wall. The progressive retroperitoneal or intraperitoneal extension of the infection from an apparently primary focus in the appendix or intestinal tract to adjacent or distant tissues and organs may be accompanied or subsequently followed by haematogenous dissemination of the infection.

In the cases reported by Samter⁽²⁸⁾ and Eliasberg⁽²⁹⁾ the apparently primary focus of infection was situated in the ascending colon. When an abscess is found below the liver, in front of the kidney and behind the colon, even if a fistula is found in an indurated area in the colon, as in Ullmann's⁽³⁰⁾ case, the origin of infection is to be attributed to a "primary" focus in the colon when no other focus is found in the body during life or after careful examination at autopsy.

In a few cases it appears that perirenal infection or infection of the kidney itself was the result of direct extension of a focus of infection in the thoracic region.

The cases reported by the American authors Peacock,⁽³¹⁾ Cumming and Nelson,⁽³²⁾ Polayes and Lederer,⁽³³⁾ and Kindall⁽³⁴⁾ are typical examples of the results of renal infection from an apparently primary focus in the appendix. In these four cases one operation at least had been performed to allow pus to escape from an abscess which had developed in the region of

the posterior surface of the kidney before nephrectomy was performed, the last-named operation being performed at periods varying from six months to two years after the removal of an acutely inflamed, a subacutely inflamed, or in one case a chronically inflamed "atrophic" appendix.

An interesting case has been recorded by Barth.⁽³⁵⁾

The patient had suffered from symptoms of appendicitis for ten months before her death. Four months after the appearance of symptoms an abscess which developed in the lumbar region was opened and later a sinus formed in which actinomycetes granules were eventually found. The abscess cavity drained by the sinus was explored four days before death. Autopsy revealed that the major portion of the abscess cavity was situated in the right lobe of the liver, which appeared to be pulled downward by indurated adhesions. The lower and much smaller portion of the abscess was bounded by kidney, colon and indurated peritoneum. The appendix extended upward behind the colon in indurated tissue directly toward the abscess cavity, and from the tip of the appendix a strand of indurated tissue extended between the kidney and the liver and communicated with the abscess.

Brunner⁽³⁶⁾ mentions another case reported by Barth in which autopsy revealed upward extension of infection behind the left kidney toward the diaphragm in a patient whose appendix was directed downward and to the left and communicated with the upper part of the rectum.

Although not strictly within the scope of this article, a personal experience, which will possibly interest those engaged in research work on abdominal actinomycosis, may be related here as some considerable time will elapse before the section of the work dealing with actinomycosis of the intestinal tract is published.

This case may serve to lend support to the contention that operative trauma may contribute to the development of actinomycotic lesions originating in the neighbourhood of the caecum. Such operative trauma may be caused by rough manipulation on the part of the surgeon or, as suggested in this case, to "instrumental" trauma associated with crushing the base of the appendix with a haemostat.

The patient, a female, aged twenty-one years, was referred to a surgical colleague by a physician with a diagnosis of subacute appendicitis. The correct diagnosis of lead poisoning was made after operation. The appendix appeared to be healthy and free from kinks, bands and adhesions. The base of the appendix was crushed, ligated and the stump buried by a purse-string suture; the wound healed slowly, and four months later three fistulae discharging offensive purulent material containing actinomycetes granules developed in the operation wound. The lowermost fistula was found to be adherent to the bladder wall for a distance of about two centimetres. The three fistulae united to form a single tract about one centimetre from a conical protrusion representing the now everted appendiceal stump which was situated near the centre of a traumatic diverticulum apparently produced by the purse-string suture.

This case impressed upon me the wisdom of applying only a ligature to the base of the appendix so as to reduce the operative trauma to a minimum. This practice is commended in view of the fact that, as a result of the bacteriological examination of appendices removed at operation in this district, it is observed that actinomycetes which can be cultivated under micro-aerophilic or anaerobic conditions are present in approximately 8% of cases.

It must be remembered that in certain cases of actinomycosis in which the kidneys are definitely involved and in which the infection has developed subsequent to the removal of an inflamed appendix, although the caecum may be adherent to the operation wound and the extraperitoneal or muscular tissues of the neighbouring abdominal wall may be the site of one or more abscesses and one or several sinuses are discharging continuously or intermittently small or large amounts of thin serous or thick purulent material, the general peritoneal cavity is free from fluid and the peritoneum itself is quite smooth, although the liver and also both lungs are firmly adherent to the diaphragm, as in Robson's⁽³⁷⁾ case, in which actinomycotic pyæmic

abscesses were found at autopsy in the lungs, brain, spleen, liver and kidneys. In other cases and particularly when a ruptured appendix has been removed, the lungs and the liver are firmly adherent to the diaphragm and the whole of the right side, and even the entire abdominal cavity, is the site of very extensive and dense fibrous adhesions which may enclose small or large intercommunicating pockets of pus which in turn communicate with abscesses in the abdominal or thoracic viscera and/or with the external surface of the body.

To safeguard against wrong conclusions as to the probable origin of renal infection, it is very essential to make a thorough and complete autopsy examination in those cases in which no operation has been performed and in which the clinical signs and symptoms do not conclusively point to an actinomycotic infection in other abdominal or thoracic organs and especially so in those rare cases in which no clinical history at all is available, as in the case of patients suffering from certain mental disorders.

In those instances of renal infection in which autopsy reveals that the periphery of the cortex of the kidney has been infected apparently by contiguity from one or more, small or large, actinomycotic lesions in the liver, it must not be concluded that the lesion in the liver is the result of cryptogenic origin somewhere in the mucosa of the intestinal tract until the buccal cavity is thoroughly examined, particularly in conditions in which the other abdominal organs, the thoracic organs, brain, bones, muscles and skin appear perfectly healthy.

In one case⁽³⁸⁾ presenting a peripheral actinomycotic lesion in the kidney which was apparently due to spread of infection by contiguity from a lesion in the liver, the only other focus of infection found in the body at autopsy was a very small circumscribed actinomycotic alveolar abscess of the first molar tooth of the right upper jaw. The liver of the patient contained two greyish-white gelatinous actinomycotic tumours, one of which was ten centimetres in diameter. It may be mentioned here that apparently primary lesions in the liver may sometimes assume a gelatinous appearance; this appearance is not characteristic of certain metastatic lesions.

In Rowland's⁽³⁹⁾ case the "fungus" was discovered in pus which was expressed from a small sinus associated with a carious bicuspid tooth soon after the patient had expectorated at least two pints of purulent sputum containing numerous actinomyces granules.

An abscess which formed in the right iliac region and which was considered to be due to suppurative appendicitis had been incised eight months previously. At autopsy, actinomycotic lesions were found in the left lung and left kidney; "the appendix, except for adhesions, was normal; a few granules were present throughout free in the lumen of the bowel".

A careful examination should be made during the life of the patient and more especially at autopsy from the crown of the head to the soles of the feet, even in the absence of any history of trauma.

When a history of gross trauma, and particularly when an apparently trivial injury would appear to be associated with a condition of pyæmic actinomycosis which caused the death of the patient, and especially when the patient has been suffering from carious teeth, it is essentially necessary to examine thoroughly the site of injury, particularly when the relatives of the deceased claim compensation from the employer for the death of the patient.

In a case⁽⁴⁰⁾ reported seven years ago, a cattle-dealer, while walking barefooted in his barn, received a slight injury to the sole of his left foot. Death ensued within five months as a result of actinomycotic pyæmia. At autopsy, in addition to actinomycotic lesions in the lungs and liver, an actinomycotic abscess was found in the lower pole of the left kidney and actinomyces granules were found in the pus of a sinus in the left heel. In this case too, autopsy revealed metastatic actinomycotic osteomyelitis in the eleventh and twelfth dorsal vertebrae.

The omission of any reference to the condition of the patient's teeth was probably due to the fact that the case was not the subject of legal argument.

In another case⁽⁴¹⁾ of hæmatogenous actinomycotic osteomyelitis, the only evidence of metastasization of the infection found in the abdominal cavity at autopsy was a small wedge-shaped focus in the right kidney.

In Earl's⁽⁴²⁾ case an abscess was found in the brain at autopsy.

The right kidney was the only site of actinomycotic infection in the abdominal cavity. The kidney was only slightly adherent to the *quadratus lumborum* muscle and contained in its lower third a firm greyish mass in which a number of small cavities surrounded by dense fibrous tissue were found and which contained thick yellow pus and a few small yellow actinomyces granules.

In some cases of pyæmic actinomycosis and in which both kidneys are studded with metastatic foci, the liver and all the other organs in the peritoneal cavity may be quite free from actinomycotic infection,⁽⁴³⁾ and even despite the presence of an old-standing actinomycotic lesion in the lower lobe of one lung and discharging sinuses in the lower thoracic wall.⁽⁴⁴⁾

Some authors have observed that an apparently small primary lesion may cause extensive lesions in the organs secondarily affected—liver, lungs, peritoneum, kidneys—which show a far greater destruction of tissue than that observed at the site of apparent primary origin. Other organisms may help to cause this extensive spread of infection and destruction of tissue.

When a renal actinomycotic lesion is found to be associated with a thoracic actinomycotic lesion this last-mentioned lesion may apparently be: (i) "primary" in the thoracic wall and is occasionally attributed to trauma; (ii) an "aspiratory, primary or secondary" bronchial or peribronchial lesion and sometimes attributed to the nature of the work performed by the patient; (iii) a metastatic hæmatogenous lesion; or (iv) extension by continuity or contiguity from adjacent tissues or neighbouring organs.

Renal lesions and hæmatogenous actinomycotic thoracic lesions may occur in the same patient when apparently both a "primary" and a "secondary" actinomycotic lesion are already present in the thorax, and occasionally when the patient is suffering also from *diabetes mellitus*, pulmonary tuberculosis or syphilis.

In Mallory's⁽⁴⁵⁾ case the nature of the disease was not recognized either clinically or by macroscopic examination at autopsy. The pathological report unfortunately is not presented in detail. The small multiple "reddish-coloured" actinomycotic foci, with little or no reaction of the surrounding tissues, found in the lungs at autopsy suggest either that they possibly originated as the result of the rupture and aspiration of the pus of an actinomycotic abscess in one of the older areas of infection in the lungs or more probably that they were of hæmatogenous origin—a circumstance to which Kasper and Pinner⁽⁴⁶⁾ have called attention.

In cases of pulmonary actinomycosis or actinomycosis of the thoracic wall which have been definitely diagnosed during the life of the patient to be associated with a renal actinomycotic lesion, and in those cases in which a clinical diagnosis of actinomycosis has not been considered and only a partial autopsy examination has been permitted, the presence of an actinomycotic lesion in the wall or within the cavity of the thorax and in one or both kidneys is not sufficient evidence to justify the assumption, and much less the conclusion, that the thoracic lesion is a "primary" one and that the renal lesion is a "metastatic" infection from this primary focus of infection, if the patient's teeth have not been thoroughly examined or even when a history of recent dental extractions or repeated attacks of tonsillitis or injury in the neighbourhood of the kidney has been obtained, and particularly so in those

cases in which pulmonary or thoracic symptoms have been preceded immediately or even some time previously by gastro-intestinal symptoms.

At least sixteen other interesting cases⁽⁴⁷⁻⁶²⁾ have been reported in which renal actinomycotic lesions have been associated with thoracic actinomycotic infection.

In a few cases in which a cardiac actinomycotic lesion is found to be associated with another actinomycotic lesion in the thorax, macroscopic and microscopic examination justifies the conclusion that the cardiac lesion is due to direct extension of a pulmonary or mediastinal lesion or a lesion of the osseous or soft tissues of the walls of the thorax.

Shrewsbury⁽⁶³⁾ isolated actinomycetes, which preferred a condition of partial anaerobiosis, from dermal abscesses and from the blood of a living patient suffering from actinomycotic pyæmia. The kidneys at autopsy were found to be normal in size and the capsule stripped readily, but on section numerous small actinomycotic abscesses were found scattered irregularly throughout the kidneys.

Fellinger and Salzer⁽⁶⁴⁾ isolated actinomycetes, whose growth was more luxuriant under anaerobic than under aerobic conditions, from the pus of dermal abscesses and from the blood and splenic pulp of a cadaver. At autopsy the kidneys were found to be normal in size and the capsule stripped easily, but numerous actinomycotic abscesses, ranging in size from a pea to a cherry and filled with creamy pus, were found in the cortex of each kidney.

Freed and Light⁽⁶⁵⁾ isolated actinomycetes under aerobic conditions from the blood of a living patient suffering from actinomycotic pyæmia. Actinomycetes granules were found in the urine and sputum.

Actinomycotic lesions, found at autopsy, which developed apparently as a result of hæmatogenous spread from a recognized or unrecognized "primary" focus of infection, frequently present an interesting but difficult problem. Available literature contains a number of cases of pyæmic actinomycosis similar to that described by Münch in which not only the kidneys but also the spleen and other abdominal organs appear to have escaped infection.

In Münch's⁽⁶⁶⁾ case, autopsy failed to reveal involvement of the urinary system, although extensive actinomycotic infection was found in the lungs, pericardium and myocardium. Metastases were found in the muscles of the extremities, right testis and submucosa of the jejunum. The brain and abdominal viscera (except the jejunum) showed no evidence of infection.

In one of Werthemann's⁽⁶⁷⁾ cases which occurred in a farmer, thirty-six years old, and in which generalized actinomycotic infection appeared to have originated from a primary focus in the left lower lung, a large abscess was found at autopsy at the apex of the right ventricle.

Large metastatic abscesses were found in the subcutaneous tissue of the posterior aspect of both thighs, right shoulder region, right side of the neck, under the chin; a retropharyngeal abscess was also found. Small metastatic abscesses were found in the lower left precentral gyrus, spleen, kidneys, wall of the small intestine, and a submucosal abscess, the size of a pea, which did not communicate with the lumen, was found in the wall of the appendix. Death occurred about seven months after the onset of symptoms.

In another patient, a female aged sixty-eight years, who died within ten months of the commencement of her illness, numerous actinomycotic abscesses were found at autopsy in both lungs and in the brain; a few small abscesses were found in the spleen and right kidney; bilateral actinomycotic paranephritis and complete destruction of the bodies of the first and second lumbar vertebræ were present; as usual, the intervertebral disk was not destroyed.

The author has suggested that infection in this case originated from infected teeth and became generalized by way of the blood stream. He further suggests that from the metastases in the vertebræ the infection also spread by direct

extension externally to the skin in the upper left lumbar region and to the posterior surfaces of both kidneys and finally invaded the lower portion of the *vena cava*.

Extensive pyæmic actinomycosis has occurred not only in adults but also in children.

Paetzold's⁽⁶⁸⁾ patient, a boy aged twelve years, after an illness of one and a half year's duration, died as a result of generalized actinomycosis.

Autopsy revealed widespread lesions which originated from an apparently primary focus of infection in the right lung. The myocardium and endocardium were extensively involved and numerous metastatic actinomycotic abscesses were found at the base of the skull, in the *dura mater*, *pia mater* and cerebral cortex and in the left lung, liver, spleen, kidneys, thyroid gland, pancreas, small intestine and the epiphyses of the upper end of the right femur.

In Longo's⁽⁶⁹⁾ case, as in many other cases of pyæmic actinomycosis in which the infection involves one or both kidneys and no paranephric or perinephric actinomycotic infection is found at autopsy, the affected kidney is usually found to be increased in size, the capsule strips easily and the surface of the organ is studded with abscesses of various dimensions containing pus of varying consistency and colour in which few or numerous granules of varying size, shape, colour and consistency may be present.

When, on the other hand, definite actinomycotic paranephric or perinephric infection is also present in cases of pyæmic infection, and particularly in cases in which the kidney is apparently involved as the result of direct extension of infection from neighbouring tissues, the kidney may be more or less completely surrounded by pus; but usually the capsule is milk-white or grey in appearance and varies from a few millimetres to two or even three centimetres in thickness and may contain one or more abscesses which may communicate with one another and with the external skin or the abdominal viscera.

RELATION OF SUPRARENAL TO RENAL INFECTION.

In most cases in which a renal focus of infection is associated with an actinomycotic lesion in the suprarenal gland, the site and extent of the lesion in the suprarenal gland usually indicate whether the lesion is due to extension of infection by contiguity from the renal focus of infection or is the result of extension by continuity of infection from a perinephric or paranephric lesion which is sometimes also associated with a limited or extensive superficial lesion of the kidney.

In the case reported by Schlagenhauser,⁽⁷⁰⁾ and in at least two other cases of pyæmic actinomycosis in which the liver and suprarenal gland were the sites of actinomycotic lesions, it is difficult to decide whether the infection of the suprarenal gland was a metastatic hæmatogenous lesion or was due to extension by contiguity from the liver or was the result of extension of infection by continuity from a lesion in the pelvis.

In at least one case⁽⁷¹⁾ the actinomycotic lesion found in the left suprarenal gland was apparently a metastatic hæmatogenous infection, and in another case⁽⁷²⁾ which occurred in a boy, aged eight years, autopsy suggested that pulmonary infection had extended through the diaphragm on the right side and involved the suprarenal gland, which was the only abdominal organ affected with actinomycosis and which also showed no evidence of normal suprarenal tissue on microscopic examination.

A careful study of available literature leads one to believe that in a few cases of actinomycotic infection of the suprarenal gland the gland was infected by way of the blood stream, as well as by contiguity or continuity of infection from neighbouring organs or tissues.

Clinical Features of the Renal Infection.

Although granules have been observed in the urine in a few cases of renal actinomycotic infection, a review of the literature clearly shows that there is no other single feature which is pathognomonic of renal actinomycosis.

In cases of pyæmic actinomycosis in which a definite actinomycotic lesion is found in one or both kidneys, symptoms are frequently referred to the thoracic region, intestinal tract and occasionally also to the epididymis. In other cases the symptoms are those of chronic sepsis, and symptoms and signs suggesting renal involvement are not at all prominent. In certain renal and perirenal actinomycotic lesions the symptoms may simulate the symptoms of a cerebral lesion.

Symptoms and signs referable to the kidney are usually in the forefront of the clinical picture in cases of "primary" infection of the kidney. Hæmaturia, usually intermittent and sometimes preceded or accompanied or followed by fever of short or long duration, is often the first sign of renal involvement which attracts the attention of the patient. Pain, if present, varies in character, severity and location, depending largely on the direction of spread of the infection. Symptoms and signs referable to the bladder, though usually absent, may precede or accompany or follow development of a lesion in the kidney. In other cases the rapid or insidious development of a tumour in the region of the kidney may be the first sign to cause the patient to seek medical advice. In such cases the renal tumour is usually immovable, but in some cases, admittedly few, it is freely movable.

It must be remembered that the development of a renal tumour may be the first evidence of hæmatogenous spread of infection from another focus of infection after a period of latency which in one recorded case extended over a period of eleven years.

In some cases localized œdema, abscess formation and the development of one or more burrowing and frequently intercommunicating sinuses or fistulæ after an operation, or even without operative interference, have been initial signs of renal infection.

In a few cases reno-colonic and acquired or even possibly spontaneous reno-cutaneous fistulæ may be present even in the absence of previous signs and symptoms of perinephric infection or a history of external trauma.

Diagnosis of the Renal Infection.

In closed renal lesions it is impossible to differentiate clinically between lesions produced by the organism of actinomycosis and those produced by almost any other organism. Hæmaturia, loss of weight, absence of fever, anæmia and sometimes the presence of a palpable tumour make it impossible on clinical examination to distinguish an actinomycotic lesion from a malignant renal tumour.

One must ever be "actinomycosis-minded", always remembering the possibility of the occurrence of actinomycotic infection in all inflammatory and neoplastic disorders in the region of the kidney. The clinical diagnosis is easy in those relatively rare cases in which non-calcareous granules are voided in urine discoloured with blood cells and a tumour is present in the region of the kidney, and particularly when one or more sinuses or fistulæ are also present in the neighbourhood of the kidney. It must be remembered, however, that the presence of actinomyces colonies in the urine is not conclusively diagnostic of renal actinomycosis. They may appear in the urine as the result of the rupture of a neighbouring focus of infection into the renal pelvis, ureter, bladder or urethra.

Diagnosis is rarely made as a result of microscopic examination of the discharge exuding from one or more sinuses or fistulae before operation, although a diagnosis is sometimes made after operation and subsequent examination of the pus exuding from the operation wound,⁽⁷³⁾ or after microscopic examination of necrotic tissue obtained from a sinus which persisted after operation.⁽⁷⁴⁾

The presence of occasional or even numerous branched filamentous organisms in stained smears of centrifugalized urine or of cultures obtained from urine after ureteral catheterization⁽⁷⁵⁾ is not sufficient evidence that the patient is or was definitely suffering from actinomycosis. It is necessary to remember this fact, particularly when a patient is found to be suffering from paranephric or perinephric abscess and when microscopic examination of smears of pus obtained at operation reveals the presence of actinomyces. An interesting personal case was observed in recent years in which a patient developed a perinephric abscess probably as the result of blood-stream infection of the kidney from dental abscesses containing actinomyces with the same morphological and cultural characters as the actinomyces eventually isolated in pure culture under microaerophilic conditions from the perinephric abscess.

A correct diagnosis can be made only when actinomyces colonies are found on microscopic examination. An attempt should also be made to obtain cultures of the organism under favourable conditions in media suitable for aerobic, microaerophilic and anaerobic growth.

It is important to remember, too, that the presence of macroscopic granules does not necessarily mean that the lesion is due to the organism of actinomycosis. Small masses of tumour cells, tuberculous debris, small urinary calculi *et cetera* may be mistaken for actinomyces granules unless a microscopic examination is made.

Recht⁽⁷⁶⁾ and a few other authors made the correct diagnosis of the renal condition found at autopsy only after microscopic examination of material obtained from the kidney.

It is necessary to make a careful and complete autopsy examination. A few authors who have found a lesion in the kidney have either neglected to examine or at least to report on the microscopic examination of the pathological condition found in the kidney, although reporting actinomycotic lesions in the lungs, liver, heart and other organs in detail.

When an operation is performed to release the contents of an abscess which has developed after appendicectomy or any pelvic operation, or when any inflammatory lesion in or around the kidney is relieved by surgical measures or examined at autopsy, it is absolutely essential to have an immediate systematic bacteriological examination made of the maximum amount of purulent material obtainable, and also later a careful histological examination of any inflammatory or neoplastic mass removed at operation or autopsy.

Diagnosis is sometimes suggested at operation on account of the nature of the pus evacuated from a perirenal abscess or from rupture of an actinomycotic abscess in the kidney during delivery of the organ or from the presence of granules in the renal pelvis after removal of the kidney.

In the case reported by Bedrna and Pavlica,⁽⁷⁷⁾ although the urine was not found to contain any organism previous to operation, the pelvis of the excised kidney was found to contain actinomyces granules which the authors believed were forced into the renal pelvis as the result of operative manipulation.

The urine in Kunith's⁽²¹⁾ patient, on whom right nephrectomy was performed for an apparently primary actinomycotic lesion, was found to

contain actinomyces colonies and "clusters of filaments" for five weeks after operation. Kunith believed that their presence in the urine was due to mechanical pressure on the tumour which forced the colonies into the ureter at the time of operation. He is not unmindful of the fact that, although the renal pelvis and the commencement of the ureter showed no macroscopic evidence of infection at the time of operation, the possibility of actinomycotic infection of the remaining portion of the ureter could not be excluded.

At a clinical meeting Sixl⁽⁷⁸⁾ exhibited a patient and demonstrated actinomyces colonies, before actual operation was performed, in pus obtained by exploratory puncture with a syringe from an abscess in the region of the right kidney and also in a submandibular abscess in a patient whose illness had run an afebrile course.

The coexistence of unilateral renal actinomycosis and nephrolithiasis is not common.

If a calculus is found at operation, it is interesting to ascertain if the calculus is a "fossilized mass of actinomyces", as in Israel's case, remembering at the same time that staphylococci and other organisms have been found "fossilized" in the renal pelvis, and in some cases possibly have been the cause of the recurrence of calculus formation and also the probable cause of other lesions in the kidney which developed at a later date.

It is well to remember that the kidney and liver in at least a few apparently healthy experimental laboratory animals appear to act as a filter for certain types of the organism of actinomycosis.

Although man appears to have a natural high resistance to actinomyces infection, it must be remembered that injuries of the renal parenchyma are more common after trauma than injuries to the pelvis and that the organism of actinomycosis may be carried in the blood stream and may set up inflammation in the kidney when conditions are favourable for colonization of the organism, particularly in patients who have carious teeth and have also suffered from the effects of external or operative trauma in that region.

As echinococcus disease is prevalent in Australia, and since at least one case⁽⁷⁹⁾ of hepatic actinomycosis has been associated with the presence in the liver of hydatid cysts which dominated the clinical picture and course of the patient's illness, it is wise to remember the possible coexistence of these two diseases when hydatid disease is found in one or both kidneys, especially when one or more operations have been performed for renal echinococcal infection.

In this particular case of echinococcus infection and actinomycosis of the liver the latter disease was diagnosed at autopsy. Five operations had been performed for hydatid disease of the liver during the two years previous to the death of the patient. Autopsy did not reveal evidence of any actinomycotic lesion in the digestive tract. Although the absence of evidence of actinomycotic infection of the intestine does not justify the assumption that the lesion did not arise from the alimentary tract, even although symptoms of disturbance of gastro-intestinal function were also absent, one cannot overlook the fact that operative trauma may have been associated with and possibly contributed to the colonization of actinomyces in the liver.

As in other regions of the body, so too in cases of renal actinomycosis, the coexistence of two or more diseases must always be remembered, and particularly venereal infection and tuberculosis.

One interesting and instructive case of generalized pyæmic actinomycosis has been recorded⁽⁴⁹⁾ in which actinomycotic abscesses were found at autopsy in the kidneys, while tuberculous lesions were found to exist in immediate proximity to actinomycotic lesions in the right lung, small intestine and

liver. After describing the lesions in different regions in detail, the author concluded that

there was no interaction between the tubercle bacillus and the actinomycetes, either of antagonistic or symbiotic character. The two organisms apparently existed rather indifferently side by side upon the same nutrient medium, both thriving rather well, neither hindering nor abetting the other, but each developing the pathological action peculiar to its own nature—a state which might properly be called neutralism.

Although I am unable to find a recorded case in which carcinoma or sarcoma has been found to be associated with an actinomycotic lesion in the kidney, the notoriously deceptive macroscopic appearance of actinomycomata, when associated with malignant disease in other situations, should always make us careful to examine microscopically each and every apparently simple or malignant nodule found in one or both kidneys after operation or at autopsy.

Since renal actinomycosis is usually haematogenous in origin and may be the only manifestation of actinomycosis in the abdomen, we must remember that any patient who is the subject of a definite actinomycotic lesion in any other part of the body, may sooner or later develop a lesion in the kidney which may be unaccompanied by any clinical signs or symptoms suggesting renal involvement. A repeated regular systematic examination of the urine should be practised generally in the case of every patient under treatment for actinomycosis in any other region of the body, and particularly in cases in which the genito-urinary history is completely normal and in which blood cells have been found on microscopic examination of the urine, and especially when the examination also fails to reveal the presence of tubercle bacilli.

Cystoscopy, retrograde and excretion pyelo-ureterograms showing a disseminated moth-eaten appearance of the pelvis and ureter in cases in which tubercle bacilli are not found on repeated examination of well centrifugalized specimens of urine and in which the results of animal experiments are also negative, may assist in arriving at a correct diagnosis when the ureter and bladder are also involved.

ACTINOMYCOSIS OF THE URETER.

Bartsch⁽⁸⁰⁾ and others have reported the presence of unilateral or bilateral hydronephrosis and hydroureter due to pressure on the lower end of the ureter by indurated tissue in certain cases of pelvic actinomycosis. Two authors, each of whom performed a left nephrectomy for an actinomycotic lesion in the kidney, mention that the ureter was "greatly" thickened, and one of them considered that the macroscopic appearance of the pathological condition found in the ureter at operation "was compatible with the thickened ureter such as one sees in tuberculosis".

After autopsy examination and sometimes after surgical operation, a few authors who have reported cases of renal actinomycosis have commented on the fact that, although actinomycotic pus and débris had apparently passed through the ureter, bladder and urethra for some considerable time from at least one kidney, definitely proved to be the seat of an actinomycotic lesion which communicated with the pelvis of the kidney, the mucous membrane of the corresponding ureter, bladder and urethra presented a healthy appearance.

In a case reported by Ammentorp⁽⁸¹⁾ a fistula, which traversed the bladder wall and opened in an ulcerated area in the mucous membrane of the right lateral wall of the bladder in the region of the fundus, was found at autopsy to communicate with a retrocaecal actinomycotic abscess which apparently originated from the appendix. The wall of the right ureter was adherent to infiltrated muscle on the posterior abdominal wall in the region of the abscess and its lumen was contracted. The wall of the ureter in this situation was also infiltrated, and the pelvis and calyces of the kidney and the upper portion of the ureter were dilated.

In a case of pelvic actinomycosis reported by Hart,⁽⁸²⁾ autopsy⁽⁸³⁾ revealed extensive hæmorrhage and suppuration along the left side of the pelvis and abdomen and perforation of the left ureter and rectum.

Actinomycotic abscesses were also found in both lungs. The left ureter was eroded and perforated about one inch from the bladder and pus and blood could pass freely into the bladder. As a result, the bladder contained about a pint of recent blood clot. The ureter above the point of perforation was considerably dilated and doubtless there had also been some escape of urine into the retroperitoneal abscess cavity. Staphylococci and actinomyces colonies were found in the retroperitoneal abscess cavity and in the secondary pulmonary abscesses.

In a case reported by Cumming and Nelson⁽⁸²⁾ the patient, a female aged thirty-six years, developed an abscess in the right lumbar region within a month after the removal of a chronic atrophic appendix. Cystoscopic examination two months after appendectomy was performed revealed no abnormality in the bladder and both ureters were catheterized with ease.

A right pyelogram, after three attempts to inject the pelvis (a total of 48 cubic centimeters of sodium iodide solution being used) showed only a faint outline of the pelvis, the ureter seemingly being stretched around a tumour mass. The differential urine showed many pus cells from the right kidney, a few from the left, and negative cultures. A second cystoscopy performed one month later gave the same bladder findings. Upon catheterising the right ureter, an obstruction was met at seven centimeters. After some manipulation the catheter was passed to the region of the kidney, where another obstruction was met. A pyelo-ureterogram showed multiple strictures of the ureter with irregular areas of pelvic dilatation. There was pyonephrosis, involving the upper and lower major caliceal areas, with disturbance of the kidney substance adjacent. The pyelogram was typical of a moderately advanced tuberculosis.

Right nephrectomy was performed about six months after the appendix was removed. Subsequent examination of the kidney revealed the actinomycotic infection of the kidney.

It is wise to remember that gentle and careful intraureteral manipulation of the ureteric catheter is essential, particularly when pathological changes are present in the ureter.

A study of pyelo-ureterograms obtained either by retrograde or excretion pyelography is interesting. Obliteration of the pelvic curve of the ureter, as determined by a shadowgraph catheter in cases in which no apparent lesion is found in the kidney or ureter, may possibly be due to a stiff catheter acting as a splint. The straightening out of the pelvic curve of the ureter is to be accepted as a ureterographic sign of a pathological lesion in the ureter only when one or both ureters are outlined by opaque catheters and unilateral or bilateral obliteration of the curve is confirmed by excretion pyelography.

From personal experience and from a study of the literature on actinomycosis of the urinary system, I feel convinced that this obliteration of the pelvic curve of the ureter, in cases in which actinomyces colonies have been determined in ureteral specimens of the urine obtained from one or both kidneys, in which a definite actinomycotic lesion has been found in the bladder or urethra, and in which tubercle bacilli have not been found on repeated examination of specimens of urine subjected to prolonged centrifugalization nor as a result of animal experiments, is due to shortening of the ureter, and this is probably the result of actinomycotic infection of the ureter. The pyelo-ureterogram simulates not only the picture of a tuberculous ureter but also that of generalized pyelitis and *ureteritis cystica*, although in the latter case the vacuolated appearance of the multiple epithelial cysts located at different depths in the wall and projecting into the lumen of the ureter serves as a differentiating factor between this disease and actinomycosis of the ureter.

The multiplicity and outline of the lesions apparently produced by the organism of actinomycosis give the lumen of the ureter an irregular moth-

eaten appearance, and also serve to differentiate the lesion from the ureterographic picture produced by blood clot.

The possibility of ureterectasis and the regurgitation of the pyelographic medium containing colonies of the organism from the bladder into the lower end or even into the whole extent of the ureter, and the possible confusion caused by air bubbles introduced into the ureter at the time of injection, and the picture obtained in some cases of calculous pyonephrosis in which thick pus is present in the ureter at the time of examination, can readily be excluded by repetition of the pyelo-ureterogram if there is any doubt that the multiple defects shown in the picture are not adherent to the wall of the ureter.

As available literature does not contain pyelo-ureterographic pictures of generalized granulomata of the ureter, or of changes produced by other mycotic infections of the ureter, or of changes in the ureter found in a patient suffering from syphilis or extensive papillomatous or malignant disease of the ureter, one is unable to compare and contrast the appearance of these lesions with those apparently produced by the organism of actinomycosis.

The word "apparently" is used because no investigator in available literature has described the pyelo-ureterographic picture produced by the organism of actinomycosis in a ureter which has been definitely found to be the site of an actinomycotic lesion at a surgical operation or at autopsy. The moth-eaten appearance and the thickened and dilated ureter which is the site of one or more "strictures", as occurs in some cases of tuberculous ureter, may also be found in other cases in which actinomyces colonies are found in specimens of urine obtained after ureteral catheterization and in which definite colonies of actinomyces are found in the bladder or urethra.

ACTINOMYCOSIS OF THE BLADDER.

Pasteau⁽⁸⁴⁾ and his co-authors in a review of available literature up to 1920 were able to collect ten cases in which the bladder was involved, six of which were found at autopsy to be associated with actinomycotic lesions in the intestine.

A careful study of available literature up to 1936 and of my own cases leads me to believe that the organism of actinomycosis may cause inflammatory lesions in the immediate surrounding tissues of the bladder or actual involvement of the mucous membrane or muscular wall of the bladder, as the result of (i) spread of infection from a recognized or unrecognized focus of infection in the skin or musculature of the lower abdominal wall or perineum, (ii) the direct or indirect effects of external or operative trauma, (iii) spread of infection by contiguity from adjacent organs, (iv) retro-peritoneal spread of infection by continuity from neighbouring tissues, (v) hæmatogenous invasion, (vi) the introduction of foreign bodies into the bladder, (vii) ureterogenous invasion or secondary transmission of the organism or colonies of the organism by way of the walls or lumen of the ureter from a focus of infection in one or both kidneys, (viii) urethrogenous invasion, (ix) a combination of two or more of these modes of infection.

Israel,⁽⁸⁵⁾ Wolff,⁽⁸⁶⁾ Körte,⁽⁸⁷⁾ Middeldorp,⁽⁸⁷⁾ Bostroem,⁽⁸⁸⁾ Samter,⁽²⁸⁾ Redtenbacher,⁽⁸⁹⁾ Ransom,⁽⁹⁰⁾ and Godlee⁽⁴⁾ were among the first to observe the presence of vesico-intestinal and vesico-abdominal fistulæ in some cases of pelvic actinomycosis.

It is well to remember that a single fistulous opening in the abdominal wall may be connected with multiple tortuous intercommunicating fistulous passages throughout almost the entire abdominal cavity, some of which may also communicate with the bladder and rectum.⁽⁹¹⁾

Early writers also observed that infection of the mucous membrane or muscular wall of the bladder may be preceded or accompanied or subsequently followed by vesical phenomena in the form of tenesmus, pain referred to the body or extremity of the penis or to the vulva, frequent micturition, incomplete evacuation of the bladder, pyuria, hæmaturia, localized or extensive oedema of the penis, scrotum, vulva, one or both feet, legs, thighs or lower part of the abdomen. One or more sinuses or fistulae frequently aggravate the patient's condition, and if tenesmus and diarrhoea are superadded, cachexia is increased and death soon ensues, particularly when upper abdominal and thoracic infection are also present.

Partsch,⁽⁷¹⁾ one of the early writers, observed that disturbances of micturition were the earliest symptoms in his case to which the attention of the patient was directed. Hesse⁽⁹²⁾ and a number of other authors since his time have observed that disturbances of micturition and pathological changes in the urine were late symptoms and signs in many cases of pelvic actinomycosis in which a tumour had developed in the pelvis or lower part of the abdomen early in the course of the patient's illness, while Ullmann,⁽⁹³⁾ another early writer, observed that disturbances of micturition and pathological changes in the urine appeared about the same time as a tumour developed in the lower part of the abdomen.

In a few cases in which a definite actinomycotic lesion has been found in the lower portion of the abdominal wall and signs and symptoms of bladder involvement have been present, we have no proof of actual involvement of the bladder wall, as in Gagen-Torn's⁽⁹⁴⁾ case in which the patient was apparently well seven years after completion of treatment.

In other cases in which an actinomycotic lesion has involved the musculature of the lower part of the abdominal wall, the bladder wall has been found to be greatly thickened and adherent to the actinomycotic mass; in one case⁽⁹⁵⁾ the bladder was accidentally torn during an operation, and in another⁽⁹⁶⁾ a portion of the bladder wall was deliberately resected in an endeavour to effect complete removal of the infection. The patient was apparently well five years later.

Harris⁽⁹⁷⁾ has mentioned a case of actinomycosis of the prevesical space which occurred in a country boy and in which he believed the infection to have been hæmatogenous in origin, as he was unable to find any focus of infection in the intestinal tract. In the short record available to me no mention is made of a history of trauma.

Sattler⁽⁹⁸⁾ has described an interesting case of a boy, nine years old, who developed a tumour in the abdominal wall, extending from the symphysis to the umbilicus, and which caused the "vertex of the bladder to dip into the vesical cavity like a funnel". The patient did not complain of any urinary disturbances, his urine was quite clear and cystoscopic examination did not reveal any abnormality in the mucous membrane of the bladder.

In cases of pelvic actinomycosis the appendix, colon or loops of small intestine may be loosely or firmly adherent to one another and also to the bladder wall. Sometimes an actinomycoma or an actinomycotic abscess may intervene between the appendix or intestine and the wall of the bladder.

In one of the earliest cases reported⁽⁸⁸⁾ the actinomycotic lesion was an accidental autopsy discovery in a woman, aged sixty years, who died as a consequence of chronic nephritis. In this case the appendix terminated in a perfectly natural manner and a localized encapsulated tumour, the size of a walnut, was found at its extremity. This tumour was adherent to the bladder and contained caseous actinomycotic granulation tissue.

Vesico-abdominal or vesico-intestinal fistulae have been regarded by some authors as an attempt on the part of Nature at spontaneous cure of a pelvic or abdominal actinomycotic lesion. These fistulae are usually the result of

operative interference, but sometimes are due to the spontaneous rupture of an actinomycotic lesion in the abdominal wall, in the intestinal tract and particularly lesions of the appendix and rectum, or in the female internal genital organs.

Urinary fistulae may be found not only in association with actinomycotic lesions within the pelvis or peritoneal cavity but also with retroperitoneal lesions, as in Düring's⁽⁹⁹⁾ case in which a vesical fistula was present and actinomyces granules were found in the urine. Apparently the actinomycotic lesion was not associated with infection of the pelvic viscera. At autopsy the bones of the pelvis, lumbar vertebrae and sacrum showed marked osteoporosis and erosion.

In one case of actinomycosis of the prostate gland,⁽⁹⁰⁾ an abscess apparently ruptured into the bladder and actinomyces granules were voided in the urine. The patient was apparently well nine months after the termination of treatment.

Prig⁽¹⁰⁰⁾ has described the autopsy findings in a case of pelvic actinomycosis which occurred in a male, aged forty-one years, and in which infection possibly originated in the appendix.

Multiple fistulae communicated with the rectum, ileum and bladder. The muscular wall of the bladder was hypertrophied and the mucous membrane was definitely thickened and greyish-white in colour, except in the region of the trigone, which showed greyish-black pigmentation. Numerous light-ochre coloured areas, which varied in size from a hemp seed to that of a bean, were also observed in the mucous membrane of the bladder. In these areas a few fine fistulous passages could be followed for some distance with fine wire probes. No noteworthy changes were found in the ureteral orifices or ureters. On microscopic examination of sections of the bladder wall numerous fistulous passages were seen pursuing a tortuous course through the bladder wall from without inward. The lumen of the fistulae contained pus and actinomyces colonies. The fistulae in many places had wide openings in the mucous membrane, so that ulcers of various sizes were observed in the vesical mucosa. Actinomyces colonies were also found attached to the floor of some of these ulcers.

Poncet⁽¹⁰¹⁾ and also Delore⁽¹⁰²⁾ have reported an interesting case of ano-rectal actinomycosis in a male, aged fifty-eight years, from whose bladder and prostatic urethra several fragments of calculi had been removed at a number of sessions of lithotripsy.

In one fragment a vegetable seed was found, and in another a portion of a grain of wheat. The patient admitted that he had introduced a grain of wheat into his urethra about four months previously. Michailoff⁽¹⁰³⁾ mentions that Poncet performed a suprapubic cystostomy about six months later and removed a calculus about the size of a large hazel-nut, containing débris from a grain of wheat as nucleus. Microscopic examination of the vegetable débris revealed "the presence of characteristic actinomycotic mycelium".

Cystoscopic examination in the cases of renal actinomycosis reported by Kleinschmidt,⁽¹⁷⁾ Pinner,⁽⁵⁷⁾ Racic,⁽²³⁾ Schneider⁽²⁴⁾ and Kretschmer and Hibbs⁽²⁰⁾ did not reveal any abnormality in the mucous membrane of the bladder. In Racic's case, which was diagnosed clinically as calculous pyonephrosis, application of pressure to the renal tumour induced the usual "tooth paste phenomenon" found in these cases. Cystoscopic examination in Pinner's case revealed "ten white granules, larger than pinheads, which floated freely in the bladder".

In the brief report by Orator and Maiditsch⁽¹⁰⁴⁾ mention is made of a case of renal actinomycosis in which cystoscopic examination revealed "redness and inflammatory changes in the mucosa around the orifice of the right ureter".

Examination of the bladder, in a case of retroperitoneal actinomycosis with involvement of the right kidney reported by Russell,⁽¹⁰⁵⁾ showed

the mucosa to be diffusely reddened and, over an area two centimetres in diameter on the left side posteriorly, the mucosa was roughened and black. At this site matted coils of intestine were adherent to the bladder.

An area of bullous œdema on the right side of the bladder, due to irritation from extravescical actinomycotic infection, was found in Daniel's⁽¹⁰⁶⁾ patient, and two ulcers were also present in the mucous membrane of the base of the bladder, one of which exuded pus when pressure was applied to the right adnexa.

Verocay's⁽¹⁰⁷⁾ patient, aged fourteen years, suffered from actinomycosis of the uterus, and at autopsy was found to have bullous œdema of the mucous membrane of the bladder.

Bloch⁽¹⁰⁸⁾ states that in his case

the inward protrusion of the mucous membrane of the bladder was œdematous and peculiar formations, varying in size from a lentil to that of a bean, were seen which were covered with fibrin. The pathological changes present differed from the changes induced by bullous œdema, in that the formations were flat and not transparent.

Cystoscopic examination of Herger's⁽¹⁰⁹⁾ patient, in whom the infection was apparently confined to the bladder at the time of observation, revealed

a large elevated tumour-like mass on the fundus and right wall of the bladder. The mucosa covering this mass was deeply injected and from the surface of the mass there were numerous polyp-like projections. In the centre of the mass there was an area of ulceration. The left ureteral orifice was easily identified and normal in appearance. The right ureteral orifice could not be identified.

In this case the author was unable to decide definitely the mode of invasion of the infection into the bladder. Excretion pyelograms and the failure of the right kidney to excrete indigo-carmin administered intravenously suggested that the right kidney had been the site of a destructive inflammatory condition some time previously.

Examination of the bladder in Köster's⁽¹¹⁰⁾ patient revealed

a mass larger than a five-mark piece at the vertex of the bladder. It had a glistening red appearance and was spherical in shape. There was a total of eight or ten villous formations similar to polypi which were about two or three centimetres long. The tissue surrounding the mass was not inflamed and there was no evidence of ulceration on the surface of the tumour.

An infiltrated area in the lower abdominal wall was incised, the actinomycotic tumour of the bladder excised, and an actinomycotic abscess in the prevesical space curetted and drainage instituted.

Wildbolz⁽¹¹¹⁾ states that:

The cystoscopic findings in actinomycosis of the bladder are not characteristic; the picture is similar to that observed when a tubercular intestinal lesion or an intestinal tumour invades the bladder. The mucosa of the bladder is normal in appearance except in a circumscribed area, which is reddened and œdematous with polyp-like projections, some of which are transparent, protruding into the lumen of the bladder.

Cystoscopic examination of Weiser's⁽¹¹²⁾ case revealed

a mild diffuse cystitis and a sharply defined oval area with distinct bullous œdema on the vertex of the bladder. If pressure was applied to a fluctuating mass which was situated in the abdominal wall above the symphysis pubis, slender "rays" of yellowish pus oozed out between the glistening elevations of the bullous œdema.

Examination of the bladder of Rupp's⁽¹¹³⁾ patient, whose case history is also briefly reported by Hermannsdorfer,⁽¹¹⁴⁾ presented "a picture of a malignant tumour with a broad base".

In a case reported by Breitländer,⁽¹¹⁵⁾ which was clinically regarded as carcinoma of the bladder, cystoscopic examination suggested filaria or bilharzia infection of the bladder.

Diagnosis of the Bladder Infection.

Inflammatory lesions caused by the organism of actinomycosis in the bladder and its neighbouring tissues produce signs and symptoms which frequently make it impossible by abdominal, rectal or vaginal examination,

even sometimes when aided by cystoscopic examination and excretion and retrograde pyelography, to differentiate clinically between lesions produced by the organism of actinomycosis and almost any other organism.

One must ever be "actinomycosis-minded", always remembering the possibility of the occurrence of actinomycotic infection in all inflammatory and neoplastic affections in the region of the bladder, especially in cases in which there is a history of general ill-health, loss of weight and pallor which has been observed for a long period, and in which one or more abdominal or pelvic operations have been performed, and particularly when one or more sinuses or fistulae have developed and failed to respond to conservative or surgical treatment.

X-ray examinations are essentially helpful to indicate the presence of certain types of foreign bodies and vesical calculi which, it must be remembered, may also be associated with an inflammatory lesion due to the organism of actinomycosis.

It is well to remember too, that the organism of actinomycosis may cause inflammatory and granulomatous lesions in the bones of the pelvis and vertebral column which may simulate pathological changes produced by other organisms and also by neoplastic diseases of bone.

The clinical diagnosis is easy when granules are found in the urine and in cases in which granules are observed in the thin serous or thick purulent discharge escaping from the orifice of a fistula communicating with the bladder.

Billroth,⁽¹¹⁶⁾ one of the early writers, found macroscopic granules in the urine voided by his patient.

As a result of careful and diligent microscopic examination, Bull⁽¹¹⁷⁾ and a few others have found colonies of the organism in the urine when granules suggesting the possibility of actinomycosis were not visible on naked-eye examination of a specimen of urine.

As mentioned previously, the presence of an occasional or even numerous branched filamentous organisms in pus, in urine or in sections of a granulomatous mass is not sufficient evidence that the patient is or was suffering from actinomycosis.

It is wise to remember that the *Streptothrix urethridis* has been found by cultural methods in the urethral and prostatic secretions and in the urine of patients suffering from chronic prostatitis.

In one interesting personal case a patient suffering from infection of a Fallopian tube with actinomyces was operated upon in 1925.

Three months previously a left pyosalpinx had ruptured into the bladder and numerous actinomyces were found in catheter specimens of the patient's urine. A few branched filamentous organisms were found in the purulent content of the tube removed at operation. The patient has apparently enjoyed good health since her operation.

Schwartz and Cancik,⁽¹¹⁸⁾ using material obtained by massaging the prostate gland, found the *Streptothrix urethridis* in thirteen out of twenty patients who were suffering from chronic prostatitis.

Cohn⁽¹¹⁹⁾ has demonstrated the presence of an aerobic actinomyces in the urine of a patient suffering from chronic prostatitis.

Cecil and Hill⁽⁷⁵⁾ obtained cultures of actinomyces from a ureteral specimen of urine obtained from the right kidney of a patient who was suffering from pyelonephritis, cystitis and prostatitis.

Bruni,⁽¹²⁰⁾ in his review of streptothrix infection of the urinary system, was unable to find any case recorded in the literature up to 1904 in which the infection was limited to the urinary system. He mentions the case of

streptothricosis of the lungs reported by Pearce in which metastases developed in the kidneys and brain.

Among seventy-eight cases of streptothrix infection reviewed by Foulerton⁽¹²¹⁾ in 1913, there were two cases in which the urinary system was involved; one of these was a case of renal streptothricosis and the other a case of streptothricial cystitis.

In Herger's⁽¹⁰⁹⁾ case a biopsy specimen was removed with a cystoscopic rongeur. Microscopic examination showed the specimen to consist of granulation tissue containing several colonies of actinomyces.

Minute or large granulomata of the bladder and areas of bullous oedema must be carefully examined in order to arrive at a correct diagnosis and also to determine the possible coexistence of two diseases in what may appear to be a single lesion.

ACTINOMYCOSIS OF THE URETHRA.

In available literature one searches in vain for a definite case of actinomycosis of the female or male urethra.

Otto⁽¹²²⁾ has reported a case of generalized pyaemic actinomycosis in which actinomyces granules were found in lesions in both kidneys and in the body of the penis.

Smith⁽¹²³⁾ and also Pagliere⁽¹²⁴⁾ have cultivated actinomyces from inflammatory lesions in the penis, and two cases of actinomycosis of the glans have been reported, in one⁽¹²⁵⁾ of which the patient had suffered an injury to the glans some time previous to the development of the lesion.

BACTERIOLOGICAL EXAMINATION AND INOCULATION EXPERIMENTS.

At least five authors have cultivated from the urine or from material obtained from one or both kidneys an organism with morphological and cultural characteristics similar to those described by Wolff and Israel.

The causal organism was successfully cultivated under microaerophilic conditions in two of the cases reported in this article. These cultivation experiments show that the organisms which have been isolated are definitely similar in their morphological and cultural characteristics, a description of which has been given in a previous article.⁽¹²⁶⁾

Only three authors have mentioned the results of inoculation experiments.

I have found that inoculation experiments with subcultures of the third generation have failed to produce progressive lesions when ordinary laboratory animals were inoculated and killed at intervals of from six weeks to six months. Experiments conducted on guinea-pigs show that the organism was excreted from the blood stream into the urine and bile and cultures of the organism were obtained from the urinary bladder and also the gall-bladder of the laboratory animals. Fragments of filaments and clubs were seen within the leucocytes when the urine and bile of the inoculated animals were examined microscopically.

A survey of available literature leads one to believe that it is still very questionable whether a progressive pathological process has yet been induced in ordinary laboratory animals which actually corresponds to the actinomycotic lesions found in the human subject and due to the organism isolated by Wolff and Israel.

Baroni⁽¹²⁷⁾ and Lo Cascio⁽¹²⁸⁾ have conducted experiments with *Actinomyces asteroides* (Eppinger) and produced renal lesions in laboratory animals following intraperitoneal and intravenous inoculation. Lo Cascio also directly inoculated a kidney in a number of animals through a lumbar incision. He found that some of the experimental renal lesions had a tendency to undergo spontaneous cure.

(To be continued.)

Case Reports.

HYDATID CYST IN THE FEMALE PELVIS.¹

By HEDLEY BROWN,
Brisbane.

THIS case, I think, is worth recording for two reasons: firstly, because of the comparative rarity of hydatid disease in Queensland, and, secondly, because of the comparative rarity of the locus, even in districts where the disease is more prevalent.

Mrs. S.L.H., aged eighteen years, attended my out-patient clinic at the Brisbane Hospital in December, 1940, complaining of pain in both iliac regions and down the thighs anteriorly for twelve months. There were no urinary or alimentary symptoms. Temperature and pulse rate were normal. She had no cough and her heart and lungs appeared normal. There was no menstrual disorder. Her urine was clear, acid, and had a specific gravity of 1020.

The patient was confined at the Brisbane Women's Hospital of a normal male child weighing six pounds on July 28, 1940. Pregnancy and labour were normal and so was the puerperium.

She is one of a family of ten, the others being alive and well, except one who died at the age of three after an operation for peritonitis. Her father died, aged fifty-eight years, from carcinoma of the prostate gland. Her mother is alive at the age of fifty-five years and is an invalid pensioner suffering from arthritis. There is no history of hydatid disease in any other members of the family.

Her early life was spent on a cattle property where there were no sheep. She was born at Karaigin near Yarraman, Queensland. From there she resided for varying periods at Esk, Milmerran (a sheep district), Gatton, Toowoomba, Coolangatta, Milmerran again for the longest time, and finally came to Brisbane.

Her mother tells me that, as a child, she had two hobbies—namely, she was abnormally keen on eating lettuce direct from the garden without washing the leaves, and her other hobby was playing with her three dogs, two cattle dogs and one fox terrier. The latter had to be destroyed because of a growth on its shoulder which burst. She did not see the contents of the growth.

She was operated on by Dr. Mervyn Hall, of Toowoomba, when she was nine years old, and he has kindly furnished me with the following report. He says that he operated on her at the Toowoomba General Hospital on October 20, 1932, because of abdominal pains recurring every few weeks. The pains, sometimes accompanied by vomiting, were generalized all over the abdomen, but mainly in the right iliac region. He writes:

On opening the abdomen by a grid-iron incision, a number of cysts were felt in the pelvis and a mid-line incision was made. The appendix was removed and hydatid cysts were removed from the wall of the abdomen near the caecum, the left broad ligament, and the peritoneum in the pouch of Douglas.

The Commonwealth Health Laboratory in Toowoomba reported as follows: "The cysts have the characteristic appearance of hydatid cysts, fibrous capsule, ectocyst and endocyst being plainly visible. Section confirms the macroscopic appearance. In the fluid are many scolices, indicating that the cysts are active."

Dr. Mervyn Hall warned the mother that recurrence of further cysts was probable. In 1938 she had her tonsils removed. She remained well until December, 1940, when she consulted me. Pelvic examination revealed a symmetrical swelling filling the pouch of Douglas and evident above the pubes. It was the size of a full-term foetal head. The uterus was small and anterior. The abdominal wall showed the grid-iron and mid-line incisions. She was admitted to the Brisbane Hospital early in December, 1940. Examinations were carried out with the following results.

Blood:

Erythrocytes per cubic millimetre	3,900,000
Hæmoglobin value	75%
Colour index	0.9%
Leucocytes per cubic millimetre	7,300
Neutrophile cells	56%
Basophile cells	1%
Lymphocytes	42%
Eosinophile cells	1%

¹ Accepted for publication on March 25, 1942.

Platelets were normal; there was slight polychromasia and anisocytosis.

Hydatid complement fixation test produced no reaction. The result of the Casoni test was negative.

Operation was advised, but the patient requested to be allowed out on pass until after Christmas. This was allowed, but she failed to return until August 8, 1941, when she was readmitted because of retention of urine. Dr. K. Brunnich, who sent her to hospital, reported that he had catheterized her bladder and had obtained thirty ounces of urine. Her bladder was catheterized again after eleven hours, and fourteen ounces of urine were obtained. Control of urination was established while she was resting in bed.

Further investigations were carried out as follows:

X-ray examinations were made by Dr. Cooper. After flat X-ray examination Dr. Cooper reported: "A large rounded opacity of homogeneous density filling most of pelvic cavity. Appearances are those of a cyst comparable in size to a full-term foetal head."

A barium enema report was as follows: "Rectum and sigmoid are narrowed and displaced to right pelvic wall by large pelvic cyst."

Hydatid complement fixation test again gave no reaction, but the result of the Casoni test was positive on this occasion.

Examination of the blood revealed the following information:

Leucocytes per cubic millimetre	12,000
Neutrophile cells	48%
Lymphocytes	33%
Eosinophile cells	19%

Platelets were normal.

On September 5, 1941, I operated on her with the assistance of Mr. C. A. Thelander. "Open" ether anaesthesia was employed. A mid-line subumbilical incision was made. There were a few omental adhesions to the abdominal wall and to the solitary cyst which completely filled the pouch of Douglas. Palpation of the liver gave the impression of a hard swelling—the size of an egg—on the under surface, probably a calcified cyst. The abdomen was well packed off and careful and tedious dissection was made. Care had to be taken in dissecting the cyst from the left ureter, which was somewhat enlarged. When almost free, the cyst ruptured. Ether was poured into the cavity. The cyst was then completely removed and the abdomen closed. There was no anaphylaxis and recovery was uneventful, the patient being up on the twelfth day. The cyst contained numerous daughter cysts, and Professor Duhig reported: "Typical laminated cyst of hydatid."

Two months after the operation the patient is well and has gained fifteen pounds in weight.

Surgery in Other Countries.

[In this column will be published short résumés of articles likely to be of practical value from Journals published in other countries and not readily accessible to surgeons in Australia and New Zealand.]

SLIPPED FEMORAL EPIPHYSIS.

Gunnar Wiberg (Stockholm): "*Behandlung der Epiphysiolysis Capitis Femoris, mittelst 'Nagelung'*", *Acta orthopaedica Scandinavica*, Volume xii, 1941, page 179.

IMPELLED thereto by the article written by P. Wilson in *The Journal of Bone and Joint Surgery* in 1938, Wiberg at the orthopaedic clinic in Stockholm decided to treat cases of slipped upper femoral epiphysis by the Smith-Petersen nail. In this article he reports the results as seen in fifteen patients so treated, and finds them good.



FIGURE I.



FIGURE II.

The technique of the insertion of the nail does not differ from that used in intracapsular fracture of the neck of the femur, but there are several points of interest in the article. As to diagnosis, stress is laid on the fact that a simple antero-posterior skiagram may easily fail to show the deformity, and that all such films should be taken with the patient in "Lauenstein's position", which means, with the thighs flexed and abducted. The accompanying reproductions of films of the condition illustrate this point very clearly (Figures I and II).

The time of invalidity is much shortened, the patients being able to walk on the limb without restriction in twelve weeks; and Wiberg considers that this period could even be shortened by two or three weeks. A relatively early synostosis of the epiphysis is noticed in these cases, but Wiberg doubts if the operation of nailing plays any part in producing it. No ill-effects or complications have been noticed in any of the cases. Incidentally it has been the practice in Stockholm to remove the nail when synostosis has occurred.

ARTHUR E. BROWN.

CONGENITAL CLUB-FOOT.

Elvind Thomasen (Copenhagen): "*Der angeborene Klumpfuß: Über die Mechanik der Deformität und ihre primäre Behandlung*", *Acta orthopaedica Scandinavica*, Volume xii, 1941, page 33.

THOMASEN considers that the main factor in congenital club-foot is the "supination deformity" of the posterior part of the foot, of the *os calcis* and its associated scaphoid on the astragalus, with at the same time some degree of inversion rotation of the *os calcis* on its vertical axis. The degree of *os calcis* supination can be quantitatively checked by dorso-plantar radiograms, and the calcaneo-talar angle used as a valuable

guide as to the success achieved in treatment. In such a radiogram the longitudinal axes of the calcaneus and the astragalus, if prolonged forward, make a measurable angle with each other, which in the normal foot is approximately 35° . In a valgus deformity this is increased, and in a varus condition it is diminished, sometimes down to zero (see Figures I and II). If after treatment the angle in question fails to return to nearly the 35° , there is a decided probability of recurrence of the supination. This was illustrated in a case of the author's. This was a case of double equino-varus in which both feet appeared to have been satisfactorily "remodelled" to outward view. The radiograms showed that the calcaneo-talar angle in the right foot was 35° , but in the left foot only 25° . As the feet looked so normal, and as the mother had to leave the city, the

child was allowed to depart; but at the routine inspection a month later the right foot was seen to have an angle of 35° still, but the left was evidently supinated again and the angle had still further diminished to 20° .

The treatment advocated should be commenced as soon after the birth of the child as possible, certainly within the first fortnight, and it can in many cases be completed in from four to nine weeks, the child thereafter being kept on maintenance treatment by its mother. The active treatment consists of a daily session of manipulation to correct the supination of the *os calcis*; and between the sessions, the application of a holding bandage. For the manipulations the child is laid on a flat surface.

With the hand of the from behind so that second or third finger. lower tibial epiphysis. tuberosity of the *os calcis*, which thus receives pressure in a medial and distal direction. The other hand, held in pronation, takes a grip of the foot from the inner side, so that the top of the thumb behind the medial side of the anterior portion of the calcaneus points in a lateral and dorsal direction. The radial border of the index finger presses on the dorsum of the foot, against the lateral side of the head and neck of the astragalus, so that the pressure is directed medially (see Figures III and IV). With the foot held thus by both hands, the

anterior hand is powerfully pronated further, the fore part of the *os calcis* being forced laterally on the head of the astragalus, and at the same time the whole posterior part of the foot being pronated. The equinus deformity is also corrected, for the top of the thumb presses the *os calcis* and the astragalus dorsally from the plantar side, while the



FIGURE I.



FIGURE II.



FIGURE III.



FIGURE IV.

finger on the tuberosity of the calcaneus forces this distally, good dorsiflexion of the foot thus being obtained. The position is maintained with firm pressure for one minute and the hold is then relaxed for a few minutes. The manipulation is repeated four or five times at a sitting. While the pressure is held the circulation of the foot is embarrassed and the foot is cyanosed, but this all passes off on relaxation of the grip. No anaesthetic is needed for it. The child cries lustily during the manipulation, but ceases at once with relaxation. After the first few treatments some oedema is seen on the dorsum of the foot, but during the second week this disappears, and no other complication has occurred. Although this procedure pays attention solely to the correction of the supination deformity of the posterior half of the foot, the inward flexion of the anterior half also disappears in eight or ten days, and Thomassen takes this fact to be evidence in favour of his theory as to the underlying pathological condition. During correction of the equinus factor a contracture can be felt in the flexor tendons, and forcible dorsiflexion of the toes is carried out to correct this.

Following the manipulative session the foot is powdered and bandaged over a thin cottonwool pad. The bandage reaches from the knee to the toes, and its turns are arranged so as to pull the foot over into the corrected position. If the bandage is correctly applied, no damage is done to the skin or to the circulation.

After eight or ten days of this treatment the inward angulation of the foot disappears, and only the equinus and varus deformities remain. When the varus factor disappears it signifies that the *os calcis* has been brought back into its normal position, and at this stage the progress should be checked by X-ray examination, with measurement of the calcaneo-talar angle. Further treatment is based on the results observed. The equinus factor persists longer and is rather more difficult to overcome, but it generally yields to treatment. When both of these factors are eliminated, in from four to nine weeks, the primary phase of active treatment is over, and a stage is arrived at which it usually takes a year at least to achieve by other methods. The cooperation of the mother is essential for the remaining stages, for she must continue daily some degree of manipulation and apply retaining bandages for the whole of the first year of the child's life. She is instructed to encourage active movements between the application of bandages, and when X-ray examination shows that the condition has been stabilized the child may remain out of his bandages for half an hour to an hour and a half. To proceed too quickly, however, may cause regression, and if any recurrence of the supination deformity is noticed, active treatment must be again instituted in hospital at once. In a few cases it will be found necessary to lengthen the *tendon Achillis* before the child starts to walk, and in some individual cases it is advisable after this time to fit the child with a leather holding appliance for night use to prevent the recurrence of a degree of supination.

Thomassen has treated seven patients at the orthopaedic hospital at Aarhus by this method between December, 1939, and June, 1940, and in every case the deformity was satisfactorily corrected at an age not attainable by the standard methods of treatment hitherto used.

ARTHUR E. BROWN.

Reviews.

Surgical Nursing and After-Treatment: A Handbook for Nurses and Others. By H. C. R. DARLING, M.D., M.S., F.R.C.S., F.R.F.P.S.; Seventh Edition; 1941. London: J. and A. Churchill Limited. Crown 8vo, pp. 736, with 207 illustrations. Price: 10s. 6d. net.

THE publication of the seventh edition of Mr. Rutherford Darling's "Surgical Nursing and After-Treatment" is a testimony to its success. The author claims that the present edition has been thoroughly revised. Perusal of the work confirms this. The revision, however, might have been attended by more excision. For example, Leiter's coils, wet cupping and the screw or *petit tourniquet* are therapeutic agents of a past era. Each of the twenty-seven chapters is preceded by an abstract of its contents, which the nurse will find most useful for revision purposes.

It is rather incongruous that "immunity" and "new growths" should find a place in the same chapter. This, however, does not detract from the merits of their presentation. The account given of surgical technique and the preparation for operation is excellent. For the detection of a hole in a rubber glove the sight of air escaping under water is more reliable than the sound of escaping air.

The author's dogmatism has no sound basis when he states that silk should not be used for ligatures and that sutures should always be absorbable. Halsted, that apostle of asepsis, invariably used fine silk. An important omission is an insistence

on the importance of an accurate count of "swabs" at an operation. A very good description is given of the Winnett-Orr treatment of compound fractures.

The book on the whole gives a comprehensive and well balanced account of surgical nursing. Any nurse who masters and applies its contents can face an examination with few qualms.

The following omissions might be made good in the next edition: the pre- and post-operative treatment of prostatectomy according to the Harry Harris technique, the use of Kirschner's wire in the skeletal traction of fractures, and the use of the Doremus ureameter in the urea concentration test of renal function.

It is not our function to be proof-readers, but attention may be called, we hope not ungraciously, to the following errors: "Sander's wood" for "sandal wood", "gauze bricks" for "gauze wicks" (page 171), "installation" for "instillation" (page 225), and "sharpening" for "shapening" (page 636).

Occupational Tumors and Allied Diseases. By W. C. HUEPER, M.D.; 1942. Springfield, Illinois: Charles C. Thomas. London: Baillière, Tindall and Cox. Royal 8vo, pp. 924. Price: \$8.00.

THIS encyclopædic work on occupational tumours can scarcely be commended too highly. It is a comprehensive, well arranged and admirably balanced and critical survey, clearly written by a master of the subject. It covers much more ground than is immediately apparent from the title, for the historical and experimental aspects of each section are fully outlined.

The introductory chapter is excellent. In it the author discusses the general conception of an occupational disease, the rapidly increasing complexity of man's chemical environment, and general historical, geographical and statistical aspects. He rightly insists on the fallacies inherent in the "causes of death" as at present registered, and points out the limitations of statistical arguments based on these registrations. He suggests and pleads for measures to improve the completeness of occupational and clinical records of cancer patients and to achieve accuracy in the registered causes of death by resort to proper pathological investigations, including post-mortem examination when necessary. Ensuing chapters deal in order with the occupational and accidental tumours of the skin, alimentary system, respiratory system, urinary system, hæmopoietic organs, mesenchymatous tissues, the eye, nervous system, endocrine organs and genital system. These chapters are admirable for their thoroughness and accuracy, and it is difficult to discover any serious omissions in the extensive list of papers to which the author refers, or errors in citation of these papers. An omission of some importance, however, is Brockbank's monograph on mule spinner's cancer (1941); and perhaps in discussing the experimental work on chemical substances as carcinogenic agents, the author might have made use of the comprehensive reviews by Cook, Kennaway and co-workers which appeared in *The American Journal of Cancer* in 1937, 1938 and 1940. On page 129 the initial investigation of the fluorescence spectra of tars and oils is incorrectly credited to Mayneord in 1927, whereas it was actually carried out by Hieger and published in 1930. However, for a work of this size the text and extensive bibliographies appear to be remarkably free from minor errors, and it seems clear that the writer has personally read and assimilated most or all of the original papers to which he refers—a practice which many authors whose books include massive bibliographies would do well to emulate.

In the section on cancer of the lung, Hueper joins those who believe that there is sufficient evidence warranting the conclusion that this disease has shown a genuine increase, an opinion which many workers regard as unproven. However, this difference of opinion does not detract from the value of the chapter, in which many relevant facts of interest are collected which will permit the reader to form an independent judgement on this point.

No research worker dealing with tumours, and no medical practitioner or industrialist concerned with occupational diseases, can afford to be without this comprehensive outline of the subject.

